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AF/2661

PATENT
Serial No. 09/390,420

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPEAL FROM THE EXAMINER TO THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:	Barry W. Field, et al.
Serial No.:	09/390,420
Filing Date:	September 3, 1999
Group Art Unit:	2661
Examiner:	Steven Blount
Title:	METHOD AND SYSTEM FOR TRANSMITTING TRAFFIC HAVING DISPARATE RATE COMPONENTS

MAIL STOP: APPEAL BRIEF-PATENTS

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Willie Jiles
Willie Jiles

Date: October 7, 2003
Exp. Mail Receipt No. EV 323508770 US

Dear Sir:

APPEAL BRIEF

Appellants appeal to the Board of Patent Appeals and Interferences from the decision of the Examiner mailed August 8, 2003 finally rejecting Claims 1-28 in the above-identified patent application. Appellants filed a Notice of Appeal on August 21, 2003. This Appeal Brief is being filed pursuant to the provisions of 37 C.F.R. § 1.192. Appellants respectfully submit this Appeal Brief, in triplicate, and a check in the amount of $330.00 to cover the statutory filing fee.

REAL PARTY IN INTEREST

The present application was assigned to Cisco Technology, Inc., as indicated by the assignment from the inventors to Cisco Technology, Inc. recorded November 1, 1999 in the Assignment Records of the United States Patent and Trademark Office at Reel 010354, Frame 0551.

RELATED APPEALS AND INTERFERENCES

There are no known appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in this pending appeal.

STATUS OF CLAIMS

Claims 1-28 stand rejected pursuant to a Final Office Action mailed August 8, 2003. Claims 1-28 are all presented for appeal.

STATUS OF AMENDMENTS

Appellants filed a Response Pursuant to 37 C.F.R. §1.111 on January 8, 2003 in response to an Office Action dated November 1, 2002 ("First Office Action") in which Claims 1, 5, 13-14, 17, 19, 22-23, and 26 were amended. The Examiner finally rejected Claims 1-28 in a Final Office Action mailed May 21, 2003 ("Final Office Action") and Appellants filed a Response Pursuant to 37 C.F.R. §1.116 on July 17, 2003 in which no claims were amended. Appellants filed a Notice of Appeal on August 21, 2003 in response to an Advisory Action mailed August 8, 2003 ("Advisory Action"). Consequently, the claims which are on appeal, and which appear in Appendix A of this Appeal Brief, represent the form of the claims as of the time the Final Office Action was issued on May 21, 2003.

SUMMARY OF INVENTION

A method and system for transmitting traffic having disparate rate components (74/76) includes receiving a plurality of traffic streams. Each traffic stream includes a first component (76) and a reduced rate second component (74) associated with the first component (76). The first components (76) of the traffic streams are segmented into successive cells (60). The second components (74) of the traffic streams are distributed

between a defined set of the cells (60) for in-band transmission of the second components (74).

In particular embodiments of the present invention an ATM adaption layer (AAL) cell (60) includes a payload header (62) and an AAL payload (64). (Page 11; Lines 31-32). AAL payload (64) includes a telephony control portion (74) and a telephony voice portion (76). (Page 12; Lines 7-8). Telephony voice portion (76) may include digital singal level 0 (DS-0) information (82) (Page 12; Lines 14-16). Telephony control portion (74) includes in-band Channel Associated Signaling (CAS) values (80) transmitted within AAL cell (60). (Page 12; Lines 8-10). Telephony voice portion (76) includes a set of DS-0s (82) with which successive CAS values (80) are associated. (Page 12; Lines 14-16). CAS values (80) for a portion of the DS-0s (82) may be carried in-band in each AAL cell (60) with each successive cell (60) carrying CAS values (80) for a successive set of DS-0s (82). (Page 11; Lines 19-22). CAS values (80) for all DS-0s (82) may be carried in-band within a defined number of cells (60) that together form a superframe. (Page 11; Lines 26-28). The in-band transmission of CAS values (80) does not create jittering in the AAL cell (60) stream, simplifies AAL cell (60) processing, and minimizes delay. (Page 11; Lines 28-30). Transporting CAS values (80) in-band allows frame size to exactly correspond to 48-byte ATM cell payload (54). (Page 13; Lines 27-30).

In particular embodiments of the present invention, a plurality of DS-0 (82) channels are received from customer equipment (12). (Page 15; Lines 18-20). CAS values (80) for the DS-0 (82) channels are received from customer equipment (12) as superframe information. (Page 15; Lines 20-22). DS-0 (82) streams are segmented into successive AAL cells (60). (Page 15; Lines 27-28). CAS values (80) associated with a portion of the DS-0s (82) are inserted into each AAL cell (60) in a superframe according to a suitable sequence. (Page 15; Lines 28-32). AAL cells (60) are then transmitted over a network (16). (Page 16; Lines 1-2). CAS values (80) are used at a destination node in the network (16) to determine the status of a telephone call. (Page 16; Lines 12-13). DS-0 (82) streams are reassembled at a termination node in the network (16) for delivery to the customer equipment (12). (page 16; Lines 14-16).

STATEMENT OF THE ISSUES

1. Whether Claims 17 and 22 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No. 6,212,202 issued to Radimirsch ("*Radimirsh*").

2. Whether Claims 1-16, 18-21, and 23-28 are unpatentable under 35 U.S.C. §103(a) over Appellants' admitted prior art (*AAPA*) and in view of *Radimirsh* and U.S. Patent No. 6,243,382 issued to O'Neill, et al. ("*O'Neill*").

GROUPING OF CLAIMS

Appellants have made an effort to group claims to reduce the burden on the Board. Appellants have concluded that the claims can be grouped together as follows:

1. Group 1 can include Claims 17 and 22; and
2. Group 2 can include Claims 1-16, 18-21, and 23-28.

ARGUMENTS

The rejection of Claims 17 and 22 under 35 U.S.C. §103(a) as being unpatentable over *Radimirsh* is improper and should be withdrawn. The rejection of Claims 1-16, 18-21, and 23-28 under 35 U.S.C. §103(a) as being unpatentable over *AAPA* and in view of *Radimirsh* and *O'Neill* is also improper and should be withdrawn.

A. Legal Standard – Obviousness

In order to establish a prima facie case of obviousness: (1) there must be some suggestion or motivation, either in the references themselves or in the knowledge available to one skilled in the art, to modify a reference or combine multiple references; (2) there must be a reasonable expectation of success; and (3) the prior art reference, or the combination of references, must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143.

The Examiner maintains that claims 1-28 are obvious in view of the cited references. The determination of whether an invention is obvious in view of prior art considers "if the differences between the subject matter sought to be patented and the prior art are such that the

subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains." 35 U.S.C. § 103. The fact that a prior art device could be modified so as to produce the claimed invention is not a basis for an obviousness rejection unless the prior art suggested the desirability of such a modification. *In re Gordon,* 733 F.2d 900, 221 U.S.P.Q. 1125 (Fed. Cir. 1984). Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching, suggestion, or incentive supporting the combination. *Carella v. Starlight Archery,* 804 F.2d 135, 231 U.S.P.Q. 644 (Fed. Cir. 1986). In addition, "A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention." *W.L. Gore & Associates, Inc. v. Garlock, Inc.,* 721 F.2d 1540, 220 U.S.P.Q. 303 (Fed. Cir. 1983), *cert. denied,* 469 U.S. 851 (1984). (M.P.E.P. § 2141.02). Moreover, if a "proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious." MPEP §2143.01.

In approaching this determination, a number of inquiries are made as primary considerations: (1) the scope and content of the prior art are determined; (2) the differences between the prior art and the claims at issue are ascertained; and (3) the level of ordinary skill in the pertinent art is resolved. *Graham v. John Deere Company,* 383 U.S. 1, 16, 148 U.S.P.Q. 459, 467 (1966). It is important that the proper perspective be used in considering the invention in view of the prior art while conducting the obviousness/nonobviousness analysis. It is improper for an Examiner to use hindsight having read the Appellants' disclosure to arrive at an obviousness rejection. *In re Fine*, 837 F.2d 1071, 1075, 5 U.S.P.Q. 2d 1596, 1600 (Fed. Cir. 1988). It is improper to use the claimed invention as an instruction manual or template to piece together the teachings of the prior art so that the claimed invention is rendered obvious. *In re Fritch,* 972 F.2d 1260, 23 U.S.P.Q.2d 1780 (Fed. Cir. 1992).

B. Claims 17 and 22 are allowable over *Radimirsch* because this reference fails to teach or suggest all elements of those claims.

Claim 17 of the present application recites the following:

> A telecommunications signal embodied in a transmission media comprising:
> a superframe including a plurality of cells, each cell having a payload;
> the cell payloads each comprising a successive segment of a first component for a plurality of traffic streams and a reduced rate second component for a portion of the traffic streams; and
> the cells in the superframes together comprising the reduced rate second components for all of the traffic streams.

Claim 22 recites similar, although not identical, claim limitations.

According to Claim 17, a telecommunications signal comprises a superframe made up of a plurality of *cells*. Each cell includes a *payload* that comprises: (1) a first component for a plurality of traffic streams; and (2) a reduced rate second component for a portion of the traffic streams. Claim 17 further recites that the cells in the superframe together comprise the reduced rate second components for all of the traffic streams. In particular embodiments of the present invention, the first component comprises digital signal level 0 (DS-0) information and the second component comprises control information for the first component.

Radimirsch discloses a broadband data transmission method where data is transmitted preferably in ATM cells. A narrow-band signaling channel transmits signaling information. (*Radimirsch*, Abstract). The broadband channel is comprised of an alternating arrangement of payload slots transmitted in broadband and signal data slots transmitted in narrow-band. (*Radimirsch*, Col. 3; Lines 6-8). Each payload slot contains a number of ATM *cells* with each cell containing a *header* and a *payload packet*. (*Radimirsch*, Col. 3; Lines 9-11; Items 1, 2, and 72 in FIGURE 3).

In the Final Office Action, the Examiner stated, with respect to Claim 17, that *Radimirsch* discloses a superframe with cells comprising signaling information. (citing *Radimirsch* Col. 8; Lines 33-35). The Examiner concede that *Radimirsch* does not disclose that the cell payloads contain information in addition to signaling information, but states that it would be obvious to one skilled in the art to utilize the large size of a cell payload to include non-signaling data. (Final Office Action, page 2, ¶2). As noted in the Appellants'

response to the Final Office Action, such a broad and conclusory type rejection is improper for a number of reasons. If "common knowledge" or "well known" art is being relied on, a reference should be provided in support of this position pursuant to M.P.E.P. § 2144.03. If personal knowledge is being relied on, an affidavit supporting such facts should be provided pursuant to M.P.E.P. § 2144.03. Although Appellants properly requested that the Examiner provide either references or an affidavit to support this rejection, the Examiner has provided no such references or affidavit.

Assuming, for the sake of argument, that it would be obvious to one of skill in the art to include both signaling data and non-signaling data in a cell payload, as argued by the Examiner in the Final Office Action, *Radimirsch* still fails to disclose a cell payload comprising a *successive segment* of a first component (for example, in one embodiment, data information) for a *plurality* of traffic streams and a reduced rate second component (for example, in one embodiment, signaling information) for a *portion* of the traffic streams, as recited in Claim 17. In addition, *Radimirsch* fails to disclose that the cells of the superframe together comprise the reduced rate second component for all of the traffic streams, as required by Claim 17.

Furthermore, in the Final Office Action the Examiner stated, with respect to Claim 22, that it would be obvious to one skilled in the art to carry signaling data in multiple cells. Once again, pursuant to M.P.E.P. § 2144.03, Appellants properly requested that a reference be provided in support of this position or if personal knowledge is being relied on, that an affidavit supporting such facts be provided. Although Appellants properly requested either references or an affidavit from the Examiner to support this rejection, the Examiner provided no such references or affidavit. Irregardless of the "obviousness to one skilled in the art" argument, *Radimirsch*, as discussed above, fails to disclose payloads of cells in the superframe comprising reduced rate second components in addition to first components. Assuming, for the sake of argument, that it would be obvious to one skilled on the art that a cell payload could comprise first components and reduced rate second components, *Radimirsch* still fails to disclose that substantially each cell in the superframe comprises reduced rate second components *for a same number of traffic streams*, as required by Claim 22.

Apparently abandoning the "obviousness to one of skill in the art" position of the Final Office Action in view of the Appellants' challenge to those broad rejections, the Examiner issued an Advisory Action (on August 8, 2003) arguing that *Radimirsch* does, in fact, disclose a cell payload containing signaling information and data. The Examiner noted that "in figure 4, member 80 (top of figure, far left) comprises what can fairly be considered to be a cell consisting of signaling information 73 and data sent by the mobile units (110, for example being associated with mobile unit 20)." In other words, contrary to his arguments in the Final Office Action, the Examiner takes the new position that *Radimirsch* discloses a cell having a first component and a reduced rate second component in the cell payload. However, FIGURE 4 of Radimirsch clearly shows that a reduced rate component (for example, in one embodiment, signaling information), represented by item 73 of FIGURE 4, is *not* contained within the payload slot of the cell, represented as item 72 of FIGURE 4. In contrast, *Radimirsch* discloses up-slot 80 (a cell, as characterized by the Examiner) containing a payload slot 72 containing payload data and a *signaling data slot 73 containing signaling data*. Therefore, *Radimirsch* discloses that signaling information is located within the signaling data slot of a cell, <u>not</u> within the payload slot of the cell, as required by Claim 17.

Consequently, the Examiner is unable to maintain a *prima facie* case of obviousness pursuant to M.P.E.P. § 2143 because *Radimirsch* fails to teach or suggest all the limitations recited in Claims 17 and 22 of the present application. For at least these reasons, Claims 17 and 22 are allowable over *Radimirsch*. Therefore, Appellants respectfully request reconsideration and allowance of Claims 17 and 22, as well as Claims 18-21, which depend from Claim 17.

C. Claims 1-16, 18-21, and 23-28 are patentable over *AAPA* and in view of *Radimirsh* and *O'Neill* because these references fail to teach or suggest all elements of those claims.

Claim 1 of the present application recites the following:

> A method for transmitting traffic having disparate rate components, comprising:
>
> receiving a plurality of traffic streams, each traffic stream including a first component and a reduced rate second component associated with the first component;
>
> segmenting the first components of the traffic streams into successive cells; and
>
> distributing the second components of the traffic streams between a defined set of the cells for in-band transmission of the second components in a payload of each of the cells.

Claims 14 and 23, recite similar, although not identical, limitations.

In the Final Office Action, the Examiner stated that *Radimirsch* discloses "distributing second (signaling) components in the payload portion of ATM data cells." (Final Office Action, page 3, ¶ 4, citing *Radimirsch*, Col. 8; Lines 30-35). However, the excerpt cited by the Examiner discloses utilizing all of the payload to carry signaling information and not segmenting the first components (for example, in one embodiment, data information) into successive cells and distributing the second components (for example, in one embodiment, signaling information) between a defined set of cells for in-band transmission of the second components in a payload of each of the cells, as required by Claim 1, and similarly, although not identically, by Claims 14 and 23.

Furthermore, the Examiner stated that *O'Neill* discloses "segmenting interhost communication messages generally to fit in an ATM payload." (Final Office Action, page 3, ¶ 4, citing *O'Neill*, Col. 2; Lines 26+). *O'Neill* discloses segmenting and reassembly of packets from ATM cells and states that cells containing signaling messages are distinguished from cells containing data by information contained in the header of the cell. (*O'Neill*, Col. 2; Lines 22-32). In fact, *O'Neill* specifically notes that "signaling messages and inter-host communication messages are generally too long to fit in the payload of a single ATM cell." (*O'Neill*, Col. 2; Lines 26-29). Therefore, *O'Neill* teaches away from a cell payload

containing *both* data and signaling information, as recited in Claim 1, and similarly, although not identically, in Claims 14 and 23.

In the Final Office Action, to fill the void in the prior art relating to the limitations of Claims 1, 14, and 23, the Examiner looked to the *AAPA*. The *AAPA* discloses problems with ATM adaption layer 1 (AAL1) in the way in which it transmits Channel Associated Signaling (CAS) bits for DS-0 channels. In AAL1, the CAS bits are transmitted by inserting them, all at once for all of the DS-Os, at the end of a superframe period. (Application, page 3; lines 8-15). This can result in jitter and cell clumping. (Application, page 5; lines 9-11). The Examiner conceded that the *AAPA* does not teach "segmenting the first components into streams of cells and distributing the second (signaling) components in a payload of each of the cells. (Final Office Action, page 3, ¶ 4). However, the Examiner stated that it would have been obvious to one skilled in the art at the time of the invention to segment the first components of the *AAPA* into successive cells where those cells carry signaling information in the payload, in light of *Radimirsch* and *O'Neill*. (Final Office Action, page 3, ¶6).

In addition to the fact that *Radimirsch* and *O'Neill* fail to disclose all the limitations of Claims 1, 14, and 23, as discussed above, such a broad and conclusory "obvious to one of skill in the art" rejection is improper for a number of reasons. Consequently, in the Appellants' response to the Final Office Action, Appellants properly requested either references to support a "common knowledge" or "well known art" argument or an affidavit from the Examiner to support a "personal knowledge." Contrary to M.P.E.P. § 2144.03, no such references or affidavit have been provided by the Examiner even though the Appellants requested them.

Therefore, the Examiner is unable to maintain a *prima facie* case of obviousness pursuant to M.P.E.P. § 2143 because neither *Radimirsch, AAPA,* nor *O'Neill,* whether considered alone or in combination, teaches or suggests all the limitations recited in Claims 1, 14, and 23 of the present application. For at least this reason, Claims 1, 14, and 23 are allowable over *Radimirsch, AAPA,* and *O'Neill.* Appellants respectfully request reconsideration and allowance of Claims 1, 14 and 23, and all claims that depend from those claims.

CONCLUSION

Appellants have demonstrated that the present invention as claimed is distinguishable over *AAPA*, *Radimirsch*, and *O'Neill*. Therefore, Appellants respectfully request the Board of Patent Appeals and Interferences to reverse the final rejection of the Examiner and instruct the Examiner to issue a notice of allowance of all claims.

A check in the amount of $330.00 is attached to cover the statutory filing fee. Although no other fee is believed to be due, the Commissioner is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. 02-0384 of Baker Botts, L.L.P.

Respectfully submitted,

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05073

Patent Trademark Office

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Enclosures: Appendix A – Claims on Appeal
Appendix B – Copy of U.S. Patent No. 6,212,202 issued to *Radimirsch*
Appendix C – Copy of U.S. Patent No. 6,243,382 issued to *O'Neill*

APPENDIX A – CLAIMS ON APPEAL

1. A method for transmitting traffic having disparate rate components, comprising:

receiving a plurality of traffic streams, each traffic stream including a first component and a reduced rate second component associated with the first component;

segmenting the first components of the traffic streams into successive cells; and

distributing the second components of the traffic streams between a defined set of the cells for in-band transmission of the second components in a payload of each of the cells.

2. The method of Claim 1, further comprising substantially evenly distributing the second components of the traffic streams between the defined set of cells.

3. The method of Claim 1, further comprising segmenting the first component of each traffic stream into a fixed position in the successive cells.

4. The method of Claim 1, wherein the defined set of cells is a superframe, further comprising transmitting successive superframes without insertion of intervening superframe information.

5. The method of Claim 1, wherein distributing the second component of the traffic streams between the defined set of cells comprises including in each cell payload the second component for a portion of the traffic streams such that the second components for all of the traffic streams are included within the defined set of cells.

6. The method of Claim 1, wherein the reduced rate second component comprises information received as superframe information.

7. The method of Claim 1, wherein the reduced rate second component comprises control information for the first component.

8. The method of Claim 1, wherein the first component is a DS-0 and the reduced rate second component is the Channel Associated Signaling (CAS) value for the DS-0.

9. The method of Claim 1, wherein the cell is asynchronous transfer mode (ATM) cell.

10. The method of Claim 1, wherein the first component is a DS-0, the reduced rate second component is the CAS value for the DS-0, and the cell is an ATM adaption layer (AAL) cell.

11. The method of Claim 10, further comprising repeating included CAS values in each AAL cell.

12. The method of Claim 10, further comprising providing a 4 bit sequence count in an AAL header for the AAL cell.

13. The method of Claim 1, further comprising:

storing a current value for the reduced rate second components for each traffic stream in a memory; and

retrieving the second components of traffic streams for inclusion in the cells from the memory.

14. A method for reformatting telephony traffic into asynchronous transport mode (ATM) adaption layer (AAL) cells for transmission on a network, comprising:

receiving a plurality of telephony streams, each telephony stream including a DS-0 channel and a Channel Associated Signaling (CAS) value for the DS-0 channel;

segmenting the DS-0 channels into successive AAL cells; and

including in a payload of each AAL cell the CAS value for a portion of the DS-0 channels such that the CAS values for all of the DS-0 channels are included within a superframe of AAL cells.

15. The method of Claim 14, wherein the superframe contains 24 AAL cells.

16. The method of Claim 14, wherein the superframe contains 16 AAL cells.

17. A telecommunications signal embodied in a transmission media comprising:

a superframe including a plurality of cells, each cell having a payload;

the cell payloads each comprising a successive segment of a first component for a plurality of traffic streams and a reduced rate second component for a portion of the traffic streams; and

the cells in the superframes together comprising the reduced rate second components for all of the traffic streams.

18. A telecommunications signal of Claim 17, the first component comprising a DS-0 and the reduced rate second component comprising the CAS value for the DS-0.

19. The telecommunication signal of Claim 17, further comprising the successive segments of the first component for the traffic streams having a fixed position in each cell.

20. The telecommunications signal of Claim 17, the reduced rate second component comprising superframe information.

21. The telecommunications signal of Claim 17, the reduced rate second component comprising control information for the first component.

22. The telecommunications signal of Claim 17, substantially each cell in the superframe comprising reduced rate second components for a same number of traffic streams.

23. A telecommunications device, comprising:

one or more ports receiving a plurality of traffic streams, each traffic stream including a first component and a reduced rate second component associated with the first component; and

a reformatting device operable to segment the first components of the traffic streams into successive cells and to distribute the second components of the traffic streams between a defined set of cells for in-band transmission of the second components in a payload of each of the cells.

24. The telecommunications device of Claim 23, further comprising the reformatting device operable to substantially evenly distribute the second components of the traffic streams between the defined set of cells.

25. The telecommunications device of Claim 23, further comprising the reformatting device operable to segment the first components of each traffic stream into a fixed position in the successive cells.

26. The telecommunications device of Claim 23, the reformatting device operable to include in each cell payload the second component for a portion of the traffic streams such that the second components for all of the traffic streams are included within the defined set of cells.

27. The telecommunications device of Claim 23, wherein the first component is a DS-0, the reduced rate second component is the CAS value for the DS-0 and the cell is an ATM adaption layer (AAL) cell.

28. The telecommunications device of Claim 27, the reformatting device operable to provide a 4 bit sequence count in an AAL header for the AAL cell.

APPENDIX B

US006212202B1

(12) **United States Patent**
Radimirsch et al.

(10) **Patent No.: US 6,212,202 B1**
(45) **Date of Patent: Apr. 3, 2001**

(54) **METHOD AND APPARATUS FOR TRANSMITTING DATA WHILE USING BOTH AN ATM BROADBAND CHANNEL AND A NARROW-BAND CHANNEL**

(75) Inventors: **Markus Radimirsch**, Laatzen; **Gerhard Fettweis**, Dresden; **Joerg Kuehne**, Dresden; **Branimir Stantchev**, Dresden, all of (DE)

(73) Assignee: **Robert Bosch GmbH**, Stuttgart (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/934,284**

(22) Filed: **Sep. 19, 1997**

(30) **Foreign Application Priority Data**

Sep. 20, 1996 (DE) 196 38 814

(51) **Int. Cl.**^{7} **H04J 3/24**; H04Q 7/00

(52) **U.S. Cl.** **370/473**; 370/329; 370/395; 455/451

(58) **Field of Search** 370/349, 329, 370/524, 465, 395, 473, 474, 328, 468, 330, 341, 282, 334, 336; 455/451, 450, 422, 434–5

(56) **References Cited**

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Funkschau, Nov. 1996, pp. 40 ff. cited in specification.

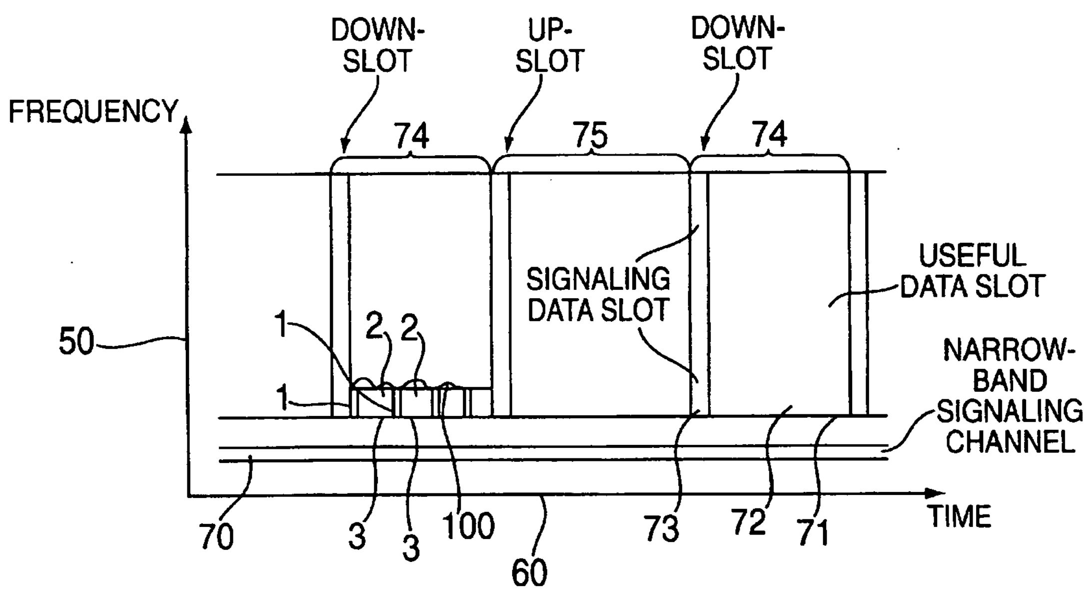
* cited by examiner

Primary Examiner—David R. Vincent
(74) *Attorney, Agent, or Firm*—Kenyon & Kenyon

(57) **ABSTRACT**

A broadband data transmission method in a wireless cellular network, the data to be transmitted being transmitted as packet-oriented data, preferably by means of ATM cells. An additional narrow-band signaling channel transmits signaling information necessary for managing the cellular, wireless network.

18 Claims, 4 Drawing Sheets



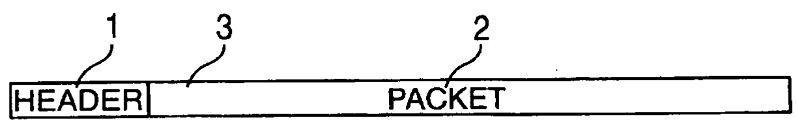


FIG. 1

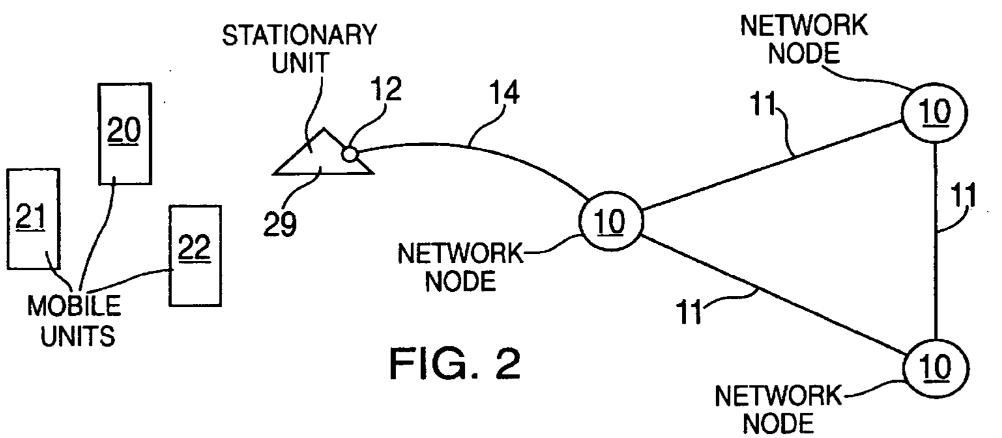


FIG. 2

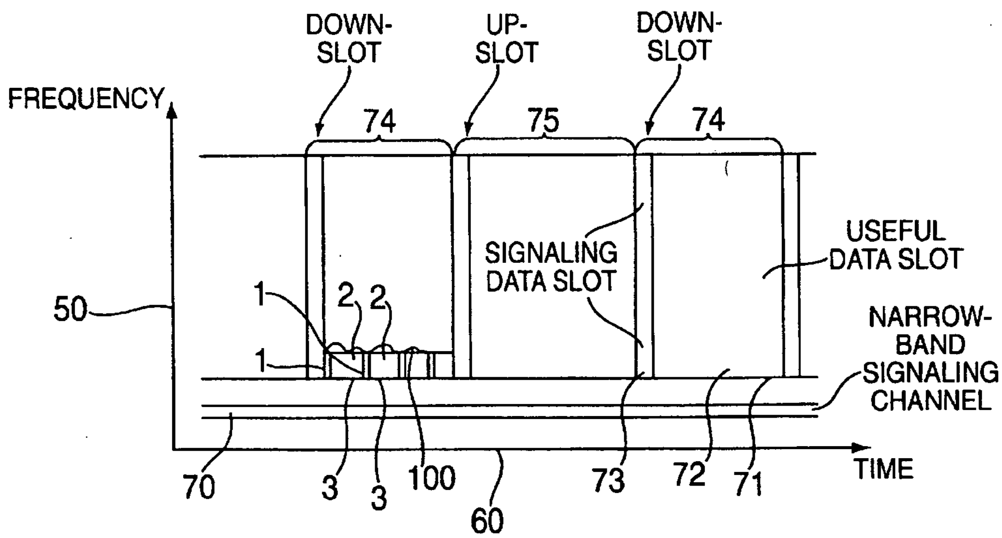


FIG. 3

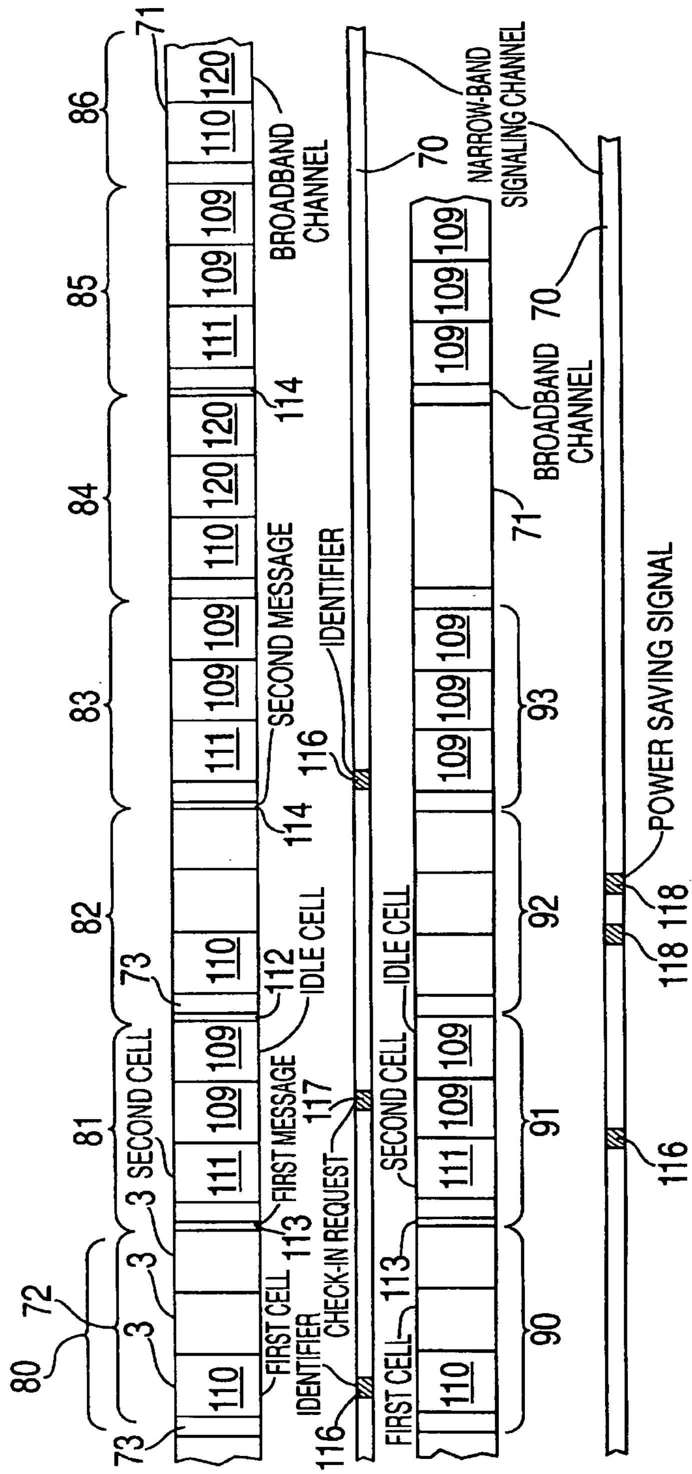

BROADBAND CHANNEL
NARROW-BAND SIGNALING CHANNEL
SECOND MESSAGE
IDENTIFIER
IDLE CELL
SECOND CELL
FIRST MESSAGE
FIRST CELL
IDENTIFIER
CHECK-IN REQUEST
POWER SAVING SIGNAL
80
72
73
71
70
81
82
83
84
85
86
90
91
92
93
109
110
111
112
113
114
116
117
118
120

FIG. 4

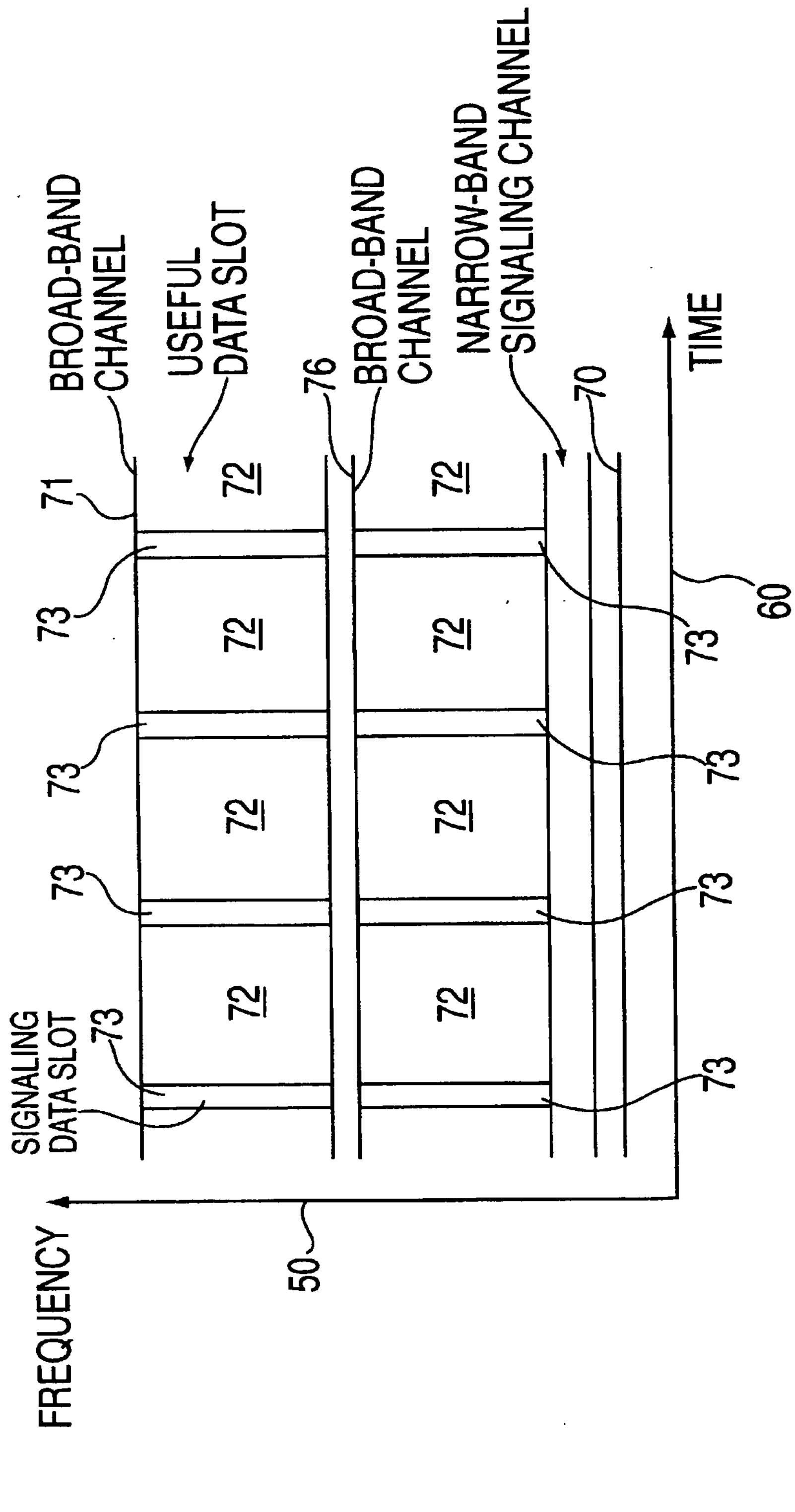

BROAD-BAND CHANNEL
USEFUL DATA SLOT
76
BROAD-BAND CHANNEL
NARROW-BAND SIGNALING CHANNEL
70
TIME
71
72
73
60
SIGNALING DATA SLOT
FREQUENCY
50

FIG. 5

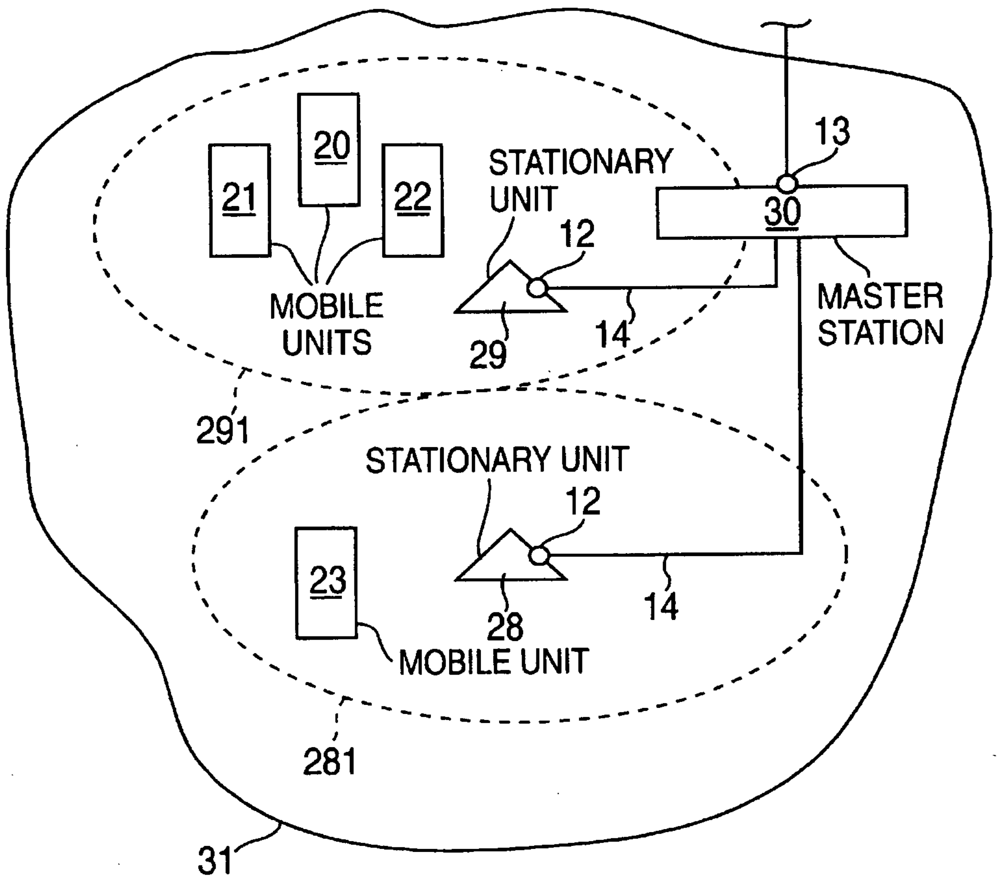

13
STATIONARY UNIT
30
21
20
22
12
MASTER STATION
MOBILE UNITS
14
29
291
STATIONARY UNIT
12
23
28
14
MOBILE UNIT
281
31

FIG. 6

METHOD AND APPARATUS FOR TRANSMITTING DATA WHILE USING BOTH AN ATM BROADBAND CHANNEL AND A NARROW-BAND CHANNEL

FIELD OF THE INVENTION

The present invention relates to a method for the wireless transmission of digital data, as well as to a telecommunication system.

A method for the wireless transmission of digital data, such as the "DECT" method, as described for example in Funkschau, issue November 1996, pp. 40 ff. This method is used when a stationary transceiver unit having a plurality of mobile transceiver units is supposed to maintain a seemingly simultaneous connection for the wireless transmission of data. For this, a specified time interval is subdivided, for example, into 24 time slots. The first 12 time slots provide for emitting data from the stationary transceiver unit, the second 12 time slots being provided for receiving data through the stationary transceiver. Each mobile transceiver unit is assigned one time slot from the first 12 time slots and one time slot from the second 12 time slots, so that a time-multiplexing method is realized. The same bandwidth and the same transmission time are provided for each possible connection, which thus results in a fixed transmission rate.

Furthermore, for the wire-conducted transmission of digital payload, the asynchronous transfer mode (ATM) method is known, as disclosed, for example, in the periodical Funkschau, issue July 1995, p. 40. Useful data, which originate from a data transmitter and are intended for a data receiver, are divided up into packets of 48 byte lengths and with headers of 5 byte lengths. The header contains information about the data transmitter and the data receiver, as well as information needed for routing the packets to the data receiver. The combination of packet and header is also referred to as a cell. A cell is transmitted over a line when transmission line capacity is available. Thus, the available bandwidth is able to be flexibly distributed among individual network subscribers.

In contrast to other packet-oriented data transmission methods, as known, e.g., from computer technology, the cell length is fixed and a continuous data stream flows on the communication paths, the data stream being filled with void cells when there are not sufficient data to be transmitted. Before a data transmission begins, a favorable path, which can have available capacity, is defined, on which all cells are then transported in that they replace void cells. This eliminates the need for transmitted packets and information to undergo error correction when correctly combining the cells into payload contents at the receiver, as is known from an ethernet.

SUMMARY OF THE INVENTION

One of the advantages of the present invention is that by using a separate, narrow-band signaling channel, a type of modulation can be selected that is insensitive to the Doppler shift of the carrier frequency because of the movement of a transceiver unit.

In addition, data can also be transmitted on a second radio frequency channel to enable an effective power-saving mode for at least one of the transceiver units. It is further beneficial, for example, to design the first radio channel as a broadband channel and the second radio-frequency channel as a narrow-band channel, since by this means the broadband is optimally adapted to the data-transmission rates to be expected.

Furthermore, it is advantageous for the transmitted packets with their headers to be configured as ATM cells, since this eliminates the need for converting the data structure in the line/radio interface, thus improving the data-transmission rate.

In addition, one of the advantages of the telecommunication system of the present invention is that it combines the capability to flexibly adapt the transmission rate with the spatial mobility of the transceiver units. Such a combination renders possible new services, e.g., multimedia services, for mobile transceiver units. Thus, it is especially advantageous to design the first radio channel as a broadband channel that is capable of transmitting the payload contents, thus making it possible to attain a high transmission rate, whereas a narrow-band second radio channel suffices for managing the wireless transmission.

It is advantageous for one of the transceiver units to be conceived as a stationary unit and to be provided with a connection for a line-conducted transmission, since this enables the telecommunication system to be interfaced with a line-conducted, broadband network, preferably an ATM network.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an ATM cell;

FIG. 2 shows a telecommunication system according to an embodiment of the present invention;

FIG. 3 shows an exemplary partitioning of a frequency band in accordance with the present invention.

FIG. 4 shows a cell stream according to an embodiment of the present invention;

FIG. 5 shows a second partitioning of the frequency band in accordance with an embodiment of the present invention.

FIG. 6 shows a second telecommunication system according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a cell 3. The cell 3 includes a packet 2 and a header 1.

Cell 3 in FIG. 1 is an example of an informational unit for a packet-supported method for transmitting data. In the exemplary embodiment selected here, cell 3 is an ATM cell, where packet 2 has 48 bytes of payload contents and the header has 5 bytes of information relevant to the transmission.

FIG. 2 depicts a broadband network in which ATM cells are able to be transmitted. The transmission network is comprised of three network nodes 10, which are linked via power lines 11. In addition, a stationary unit 29 is shown, which is provided with a connection 12. Stationary unit 29 is linked via connection 12 and a power connection line main feeder 14 to one of the network nodes 10. Also shown are a mobile unit 20, a second mobile unit 21, and a third mobile unit 22.

Mobile units 20, 21, and 22 are conceived as transceiver units, which are in radio communication with stationary unit 29. On the one hand, stationary unit 29 comprises a transceiver unit capable of establishing radio contact with mobile units 20, 21, and 22; on the other hand, it also is provided with a connection 12 allowing it to make a line-conducted contact with network node 10.

FIG. 3 illustrates the frequency- and time-division of a radio frequency band, as can be used for transmitting data

between mobile units **20**, **21**, **22** and stationary unit **29** of FIG. **2**. In this case, frequency axis **50** is plotted as a vertical axis, time axis **60** as a horizontal axis. The radio communication ensues, on the one hand, via a broadband channel **71**, on the other hand, via a narrow-band signaling channel **70**, which is configured at a lower frequency. Broadband channel **71** is comprised of an alternating arrangement of a payload slot **72** and of a signal-data slot **73**. In the exemplary embodiment selected here, payload slot **72** takes up the very much larger time slot. Four ATM cells **3** are indicated in one of payload slots **72**. Each ATM cell **3**, in turn, is comprised of one header **1** and one packet **2**. Cells **3** are arranged to follow one another chronologically, each cell using the entire usable frequency band at a specific time. For the sake of clarity, cells **3** in FIG. **3** do not extend over the entire frequency range; the purpose of wavy line **100** is to simplify the representation.

The method according to the present invention will now be elucidated on the basis of FIGS. **1** through **3**. First, an exact logical and physical division of the radio channels in FIG. **3** will be described. In narrow-band signaling channel **70**, stationary unit **29** sends out its identifier. Broadband channel **71** is comprised of an alternating sequence of payload slots **72** and signaling data slots **73**, it being necessary in the exemplary embodiment selected here to make a further distinction.

In a first pair comprised of signaling data slot **73** and useful data slot **72**, which is denoted in FIG. **3** by reference numeral **74**, data are emitted by stationary unit **29**. The segment of broadband channel **71**, which is filled by stationary unit **29**, is referred to in the following as down-slot **74**. In signaling data slot **73** of down-slot **74**, stationary unit **29** emits data, which are used for managing the wireless transmission. Numbered among these data are, for example, the allocation of transmission time to mobile units **20**, **21**, and **22**. The significance of this allocation will be discussed in greater detail in the next section. Useful data slot **72** of down-slot **74** is comprised of a sequence of ATM cells **3**. Each of these ATM cells can originate from another data transmitter and be intended for another data receiver. This information is defined in header **1** of any one cell **3**.

What all cells **3** have in common is that during the down-slot **74**, they are sent out by stationary unit **29** and are able to be received by mobile units **20**, **21**, and **22**. It should be noted, in this context, that the data transmitter does not necessarily have to be stationary unit **29**. It is conceivable, for example, that the data transmitter is a network node **10** that is going to send a message comprised of an ATM cell into mobile unit **21**. This ATM cell is transmitted via power connection line **14** to stationary unit **29**, and then sent out as an ATM cell in the stream of ATM cells in down-slot **74**. In the header of the just discussed ATM cell would be noted: network node **10** as a data transmitter and mobile unit **21** as a data receiver.

Down-slot **74** is followed by up-slot **75**, which is likewise comprised of a signaling data slot **73** and a payload slot **72**. Signaling data slot **73** of up-slot **75** makes available the transmission capacity of the message from mobile units **20**, **21**, and **22** to stationary unit **29**, which relates to managing the radio communication between the mobile units and the stationary unit. Examples of such messages are, for example, the check-in requests, request to communicate or request to send. A check-in request is understood to be a brief signaling on the part of mobile unit **20**, **21**, **22**, which is located within the transmitting and receiving range of stationary unit **29**. A request to send signifies the message of wanting to transmit a data record having a defined length and a defined priority level to stationary unit **29**. A request to communicate includes the request of establishing a bidirectional radio communication between a mobile unit and the stationary unit at a specific transmission rate.

Signaling data slot **73** of up-slot **75** is followed by payload slot **72**. This, in turn, is comprised of a sequence of ATM cells **3**, which are not shown in detail in FIG. **3**. Each cell **3**, in turn, can originate from a different data transmitter and be intended for a different data receiver. It should be emphasized, however, that the stream of cells **3** does not have to be continuous in up-slot **75**. Thus, it is conceivable, for example, that a few cells are missing, and these gaps, which would be filled in a wire-conducted ATM network with "IDLE" cells, can be filled in the up-slot by general transmission pauses of a precisely defined length. This is especially beneficial when the intention is for mobile units **20**, **21**, and **22** to have an efficient power-saving mechanism. What all cells **3** in payload slot **72** of up-slot **75** have in common is that they were sent out by one of mobile units **20**, **21**, and **22**. The exact instant when a specific mobile unit may send out cells within up-slot **75** is stipulated by stationary unit **29** and communicated in the exemplary embodiment selected here in signaling data slot **73** of down-slot **74**.

At the same time, stationary unit **29** sends out its station identifier on narrow-band signaling channel **70**. This division renders possible an efficient power-saving mode. As an example, after a certain time of no active participation in a data transmission, mobile units **20**, **21**, and **22** can lapse into a power-saving mode, in which the transmit and receive functionality is switched off for broadband channel **71**. However, the mobile unit can continue to assure, by receiving narrow-band signaling channel **70**, that it is still within the transmitting range of stationary unit **29**. Moreover, the ready-to-transmit and ready-to-receive state of the mobile unit can be re-established by way of narrow-band signaling channel **70**.

FIG. **4** shows by way of example the cell stream that is created when mobile unit **20** maintains a connection with stationary unit **29**, the connection having a low transmission rate. During this data transmission, mobile unit **21** is activated and checks in. Second mobile unit **21** then sends off a data file as a high priority and then lapses into a power-saving mode.

FIG. **4** illustrates a broadband channel **71** and a narrow-band signaling channel **70**, in which the above-described data transmission flows take place. As already shown in FIG. **3**, down-slots **74** alternate with up-slots **75**. Both down-slot **74** as well as up-slot **75** have a signaling data slot **73**, which is followed by a useful data slot **72**. Useful data slot **72**, in turn, comprises three cells **3** in the example shown here. However, it is also conceivable that up-slot **75** and down-slot **74** contain a different number of cells; likewise it is also conceivable and provided for more cells **3**, for example **10** to **70**, to be combined in one payload slot **72**. The small number of cells **3** per payload slot **72** was selected to simplify the illustration in FIG. **4**.

Individual cells have different designations, depending on their contents. First cell **110** contains messages sent out by mobile unit **20**. Second cell **111** contains messages sent out by stationary unit **29**. Third cell **109** is an IDLE cell. Fourth cell **120** contains messages from mobile unit **21**. Furthermore, messages are transmitted in the signaling slots. A first message **113** is sent out by stationary unit **29** and has as contents: "first cell for mobile unit **20**". A second message **114** has as contents, for example: "first cell mobile unit **20**, second cell mobile unit **21**, third cell mobile unit **22**." A third

message 112, which is sent out by mobile unit 21, has as contents, for example: "request to send by mobile unit 21, urgent, four cells." On narrow-band signaling channel 70, there are two messages, identifier 116 sent out by stationary unit 29 and check-in request 117 sent out by mobile unit 21, as well as power-saving signal 118.

In the data stream shown in FIG. 4, a first up-slot 80 is first considered on broadband channel 71. No messages whatsoever are dispatched in its signaling data slot 73. Payload slot 72 is comprised of a first cell 110, which was sent out by mobile unit 20, followed by a transmission pause that continues for two cell lengths. On the narrow-band signaling channel, the stationary unit dispatches an identifier 116. This dispatching of identifier 116 is periodically repeated as the process continues. A first down-slot 81 follows, whose signaling data slot contains first message 113 dispatched by stationary unit 29. This message allocates to mobile unit 20 the first cell in the next up-slot, in third up-slot 84. In second down-slot 83, the payload slot is comprised of a second cell 111, which is dispatched by stationary unit 29 and is intended for mobile unit 20, followed by two IDLE cells 109. During the same time, more or less during the dispatching of second cell ill, the mobile unit was switched on. During the dispatching of the IDLE cells, it now sends out check-in request 117, which is received by stationary unit 29.

In third up-slot 84 that follows at this point, a third message 112 is sent out in signaling data slot 73 by second mobile unit 21, in which second mobile unit 21 announces its intention to transmit an urgent message. The useful data that follow contain, in turn, a first cell, which was sent out by mobile unit 20, followed by a transmission pause that continues for two cell lengths. In the following third down-slot 85, the signaling data slot contains a second message 114, which allocates to mobile unit 20 and to second mobile unit 21 defined instants for sending out their cells. This is followed, in turn, by a second cell 111, which is intended for mobile unit 20, as well as two IDLE cells 109. In the following third up-slot 84, no signaling data are sent out by the mobile units. The useful data slot contains a first cell, which had been sent out by mobile unit 21, as well as two fourth cells 120, which were sent out by mobile unit 21.

Third down-slot 85 and fourth up-slot 86 represent a repetition of slots 83 and 84, which can continue for so long until either additional messages have to be transmitted or a message transmission is ended. Fifth up-slot 90 corresponds, in turn, to first up-slot 80, the data transmission from the second mobile unit 21 having been broken off in the meantime. In the same way, fifth down-slot 91 corresponds to first down-slot 81. At this point, the data transmission is ended, no cells are transmitted in the next up-slot 92; in next down-slot 93, exclusively IDLE cells 109 are transmitted.

Since no further data transmission takes place, mobile units 20, 21 can lapse into a power-saving mode. To report this to stationary unit 29, mobile units 20, 21 each emit a power-saving signal 118, which is received by the stationary unit. In this power-saving mode, the transmit and receive functionality for broadband signal 71 is switched off, not, however for narrow-band signaling channel 70. Thus, mobile units 20, 21, 22 can continue to receive the station identifier of stationary unit 29 and, thus, assure that they are still within the transmission range of said stationary unit.

Provision can also be made for the mobile units to be called back into the normal mode by a prompting signal sent out by the stationary unit on the narrow-band signaling channel during the power-saving mode, for example, in order to establish a connection or to receive incoming data on the broadband channel.

FIG. 5 depicts another exemplary embodiment of the present invention. A second channel diagram is shown, plotted in the same way as in FIG. 3, with a time axis 60 and a frequency axis 50. There are, in turn, a narrow-band signaling channel 70 and a broadband channel 71. Additionally, however, a second broadband channel 76 is provided. Broadband channel 71 and second broadband channel 76 are both subdivided into useful data slots 72 and signaling data slots 73, signaling data slot 73, in turn, being of a clearly shorter time duration than useful data slot 72.

The utilization of the channel diagram shown in FIG. 5 is such that signaling data are exchanged, in turn, on narrow-band signaling channel 70, and both signaling data as well as useful data are exchanged on broadband channel 71 and second broadband channel 76. Now available all the time, for example, to broadband channel 71 is the dispatching of information from stationary unit 29; data which are supposed to be sent out by mobile units 20, 21, and 22 are sent out on the second broadband channel 76. The signaling functions as well as their allocation to the narrow-band signaling channel, and to the broadband signaling channels 71, 76 do not differ from the exemplary embodiment of the present invention discussed in conjunction with FIG. 3.

The exemplary embodiments according to the present invention portrayed in FIG. 3 and FIG. 5 differ by the manner of multiplexing of their up and down signals. For this, time multiplexing was selected in FIG. 3, whereas frequency multiplexing was selected in FIG. 5. However, it is also conceivable and provided for signaling information to be transmitted in both directions on narrow-band signaling channel 70. For example, a request-to-send signal, which had been transmitted in the preceding examples on the broadband channel, could also be transmitted on narrow-band signaling channel 70. If narrow-band signaling channel 70 is a channel for the bidirectional transmission of data, then the possibility likewise exists, in turn, to either use a time-multiplexing method, narrow-band signaling channel 70 still being subdivided into slots, or to revert to a frequency-multiplexing method, narrow-band signaling channel 70 then being divided up into two narrow-band signaling channels.

Provision is likewise made for a narrow-band signaling channel 70 to be configured without multiplexing, but for bidirectional transmission. This can be implemented, for example, in that messages can be simply transmitted on the narrow-band signaling channel, as needed. When working with this method, message collisions are unavoidable, however, the integrity of a message transmission is subsequently checked. This method is comparable to a method for transmitting data between computers, i.e., on an ethernet. The fact that this method is less efficient and results in a smaller bandwidth has to be considered in view of the comparatively lower costs for additional circuitry. However, this accessing method is not suitable for broadband channels 71 and 76, since it works against the aim of specifying a broadband, wireless transmission method.

Other possibilities for slightly altering the present invention follow from another arrangement of the channels in the frequency domain. Thus, departing from the channel diagram indicated in FIGS. 3 and 5, it is quite possible and also provided for the frequency domain to be filled up, without any gaps, with one or more broadband channels and one or more narrow-band signaling channels. It is likewise possible and also provided for the frequencies of the narrow-band

signaling channels and of the broadband channels to be exchanged with one another, thus, for example, for a narrow-band signaling channel to be arranged between two broad-band channels, or even to have a higher frequency than the broadband channels.

Finally, other ways of slightly altering the present invention entail allotting the signaling functions to signaling data slots in the broadband channels and to the narrow-band signaling channels. For example, the mobile unit's request to check-in or to log on for the first time to a stationary unit can be carried out on a narrow-band signaling channel.

Another slight alteration of the method according to the present invention entails not providing any stationary unit **29**. In such a case, it is, rather, a mobile unit, e.g. mobile unit **20**, which assumes the tasks of stationary unit **29**. Mobile unit **20** allocates the channels in the up-channel or in the up-slot to the other mobile units. At the same time, it maintains a connection, preferably a wireless connection to a network node **10**. Messages to be dispatched from network node **10**, for example, to mobile unit **21** are, thus, first sent to mobile unit **20**, which then retransmits them in a down-slot or in the down-channel to mobile unit **21**.

FIG. **6** depicts a telecommunication system **31** according to the present invention. Telecommunication system **31** has a master station **30** with a central connection **13** that enables the master station to communicate with other network nodes **10** that are not shown in FIG. **6**. Master station **30** is linked via two power connection lines **14** to a stationary unit **29** and a second stationary unit **28**. For this purpose, the stationary units have a connection **12**. Stationary unit **29** and second stationary unit **28** function in the same way as stationary unit **29** in FIG. **2**. The radio range of stationary unit **29** is defined by a first radio cell **291**, which is illustrated as a dotted-line oval in FIG. **6**. In the same way, the radio range of the second stationary unit **28** is defined by a second radio cell **281**. Situated in first radio cell **291** are mobile unit **20**, second mobile unit **21**, and third mobile unit **22**; situated in second radio cell **281** is fourth mobile unit **23**.

Telecommunication system **31** is a "cellular" system, which functions in an already known way, for example as a GSM network. A stationary unit handles the transmission between master station **30** and mobile units **20, 21, 22**, and **23**. In each case, the stationary unit selected is the one best able to established radio contact with the mobile unit. When a mobile unit makes the transition from one radio cell into another radio cell, the communication path must be changed. This process is usually referred to as a handover.

For the handover, it is beneficial to tap the signaling operations of the stationary units on narrow-band signaling channel **70**. Thus, even in the power-saving mode, mobile units **20, 21, 22**, and **23** are able to detect when the transmit and receive functionality has been switched off on the broadband channel, to determine whether it would be advantageous to receive via a different base station, and to initiate a handover via the narrow-band signaling channel. It is likewise advantageous that one of mobile units **20, 21, 22**, and **23** checks in when making a reentry into a radio cell or when the unit is switched on, i.e., dispatches a sign-on ready signal to the next stationary unit. It is likewise beneficial for this check-in request to be made on narrow-band signaling channel **70**, since it can then be carried out in the power-saving mode.

It should not be of fundamental importance to the present invention which of the signaling functions, in particular, are transferred to narrow-band signaling channel **70**, and which of the signaling functions are transmitted in a signaling slot within the broadband channel. It is to be considered, however, that time-critical data are advantageously transmitted on the broadband channel. Check-in request and base identification are advantageously transmitted on the narrow-band signaling channel in order to realize a power-saving mode and a simple handover.

As a general principle, the following signaling data are able to be transferred to narrow-band signaling channel **70**:

1. Identification of the stationary unit;
2. Announcement by the stationary unit of its intention to newly connect to a mobile unit;
3. Announcement of data for an existing connection to a mobile unit, there not being any data to be transmitted for a while;
4. A mobile unit's intention to execute a handover;
5. Handover wish of a mobile unit;
6. Request to send or request to communicate, in particular when the mobile unit is awakened from the power-saving mode; and
7. Synchronization information.

It is likewise provided to configure up-slot **75** and down-slot **74** with a variable length, the length being a function of the volume of data to be transmitted. In particular, it is possible to provide a signaling data slot in the down-slot only when signaling data are also actually to be transmitted by the stationary unit to the mobile unit. In this case, it is advantageous to announce the dispatching of a signaling slot on the narrow-band signaling channel.

Provision is also made for only the down-slot to have a signaling slot. Besides the narrow-band signaling channel, two broadband paths are then open for data to be signaled from a mobile unit to the stationary unit:

1. The sending of a regular ATM cell, the data receiver being the stationary unit and the 48 bytes of payload being the signaling information to be transmitted; and
2. The sending on a "random-access" channel.

The random-access channel is comprised of at least one cell in the up-slot, which is not allocated to any specific mobile unit. Each mobile unit can send in this time (thus, this random-access channel resembles the signaling slot in the up-slot, as described above). For this reason, the integrity of the transmission is also to be checked by the mobile unit. A mobile unit can request cells in the next up-slot on the random-access channel, to then transmit the actual signaling information in said cells. The number of random-access channels can vary from up-slot to up-slot, and can be stipulated, for example, by the stationary unit, as needed. An especially rational utilization of the bandwidth is achieved with this procedure.

Finally, it is also provided to use the narrow-band signaling channel for transmitting payload for extremely low-rate services. It is possible, for example, to draw upon unused capacity in the narrow-band signaling channel for transmitting data in a simple paging system.

What is claimed is:

1. A method for the wireless transmission of a digital payload between at least two transceiver units, the digital payload originating from a data transmitter and being sent to a data receiver, the method comprising the steps of:

forming the digital payload into at least one ATM cell, the at least one cell having a packet having a predefined length and a header identifying the data transmitter and the data receiver;

providing at least one broadband first radio channel which occupies a frequency band for transmitting the at least one cell;

providing at least one narrow-band radio channel which occupies a different frequency band for communicating

first data for use in establishing another communication between the at least two transceiver units; and

transmitting the at least one cell between the at least two transceiver units via a wireless communication link, wherein the at least one broadband radio channel and the at least one narrow-band radio channel are associated with the wireless communication link;

wherein the at least one broadband radio channel includes payload slots and signaling data slots, the signaling data slots being used for communicating second data between the at least two transceiver units, the another communication being based on the first data and the second data.

2. A method for the wireless transmission of a digital payload between at least two transceiver units, the digital payload originating from a data transmitter and being sent to a data receiver, the method comprising the steps of:

forming the digital payload into at least one ATM cell including a packet having a predefined length and a header identifying the data transmitter and the data receiver;

providing at least one broadband radio channel, for transmitting the digital payload;

providing at least one narrow-band radio channel, for transmitting first data for use in establishing another communication between the at least two transceiver units; and

transmitting the digital payload between the at least two transceiver units via a wireless communication link, wherein the at least one broadband radio channel and the at least one narrow-band radio channel are associated with the wireless communication link;

wherein the broadband radio channel is divided into payload slots and signaling data slots, the signaling data slots being utilized for transmitting second data between the at least two transceiver units, the another communication being a function of the first data and the second data.

3. A method for the wireless transmission of a digital payload between at least two transceiver units, the digital payload originating from a data transmitter and being sent to a data receiver, the method comprising the steps of:

forming the digital payload into at least one ATM cell comprising a packet having a predefined length and a header identifying the data transmitter and the data receiver;

providing at least one broadband radio channel for transmitting the digital payload;

providing at least one narrow-band radio channel for transmitting first data for use in establishing another communication between the at least two transceiver units; and

transmitting the digital payload between the at least two transceiver units via a wireless communication link, wherein the at least one broadband radio channel and the at least one narrow-band radio channel are associated with the wireless communication link;

wherein the broadband radio channel is divided into payload slots and signaling data slots, the signaling data slots being utilized for transmitting second data between the at least two transceiver units, the another communication a function of the first data and the second data.

4. The method according to claim 3, wherein the payload slots transmit high-bit-rate information and the narrow-band radio channel transmits low-bit-rate information, the high-bit-rate information and the low-bit-rate information being used for establishing the connection between the at least two transceiver units.

5. The method according to claim 4, wherein: the high-bit-rate information includes at least one of a sending request and a cell allocation; and the low-bit-rate information includes at least one of an identifier of a transceiver unit, a check-in request of the transceiver unit, a power-saving signal of the transceiver unit, and a request to reserve a portion of a payload slot.

6. The method according to claim 4, wherein the high-bit-rate information includes at least one of a sending request and a cell allocation.

7. The method according to claim 4, wherein the low-bit-rate information comprises at least one of an identifier of a transceiver unit, a check-in request of a transceiver unit, a power-saving signal of a transceiver unit, and a request to reserve a portion of a payload slot.

8. A telecommunication system, comprising:

a first transceiver unit;

a second transceiver unit coupled to the first transceiver unit via a wireless communication link;

wherein a digital payload is transmitted between the first transceiver unit and the second transceiver unit via the wireless communication link, the digital payload originating from a data transmitter and being sent to a data receiver, the digital payload being divided into ATM cells which are packets of a predefined length and a header which identifies the data transmitter and the data receiver;

wherein all packets are transmitted between the first and second transceiver units via a broadband radio channel, of the wireless communication link, a narrow-band radio channel, of the wireless communication link transmitting first data for establishing the another communication between the first and second transceiver units; and

wherein the broadband radio channel includes payload slots and signaling data slots,

the signaling data slots being used for communicating second data between the first and second transceiver units, the another communication being based on the first data and the second data.

9. The telecommunication system as defined by claim 8, wherein each packet and respective header is configured as an ATM cell.

10. The telecommunication system as defined by claim 8, wherein the first transceiver unit includes a mobile unit, and the second transceiver unit includes a stationary unit.

11. The telecommunication system as defined by claim 8, wherein an identifier is transmitted on the narrowband radio channel to one of the first transceiver unit and the second transceiver unit.

12. The telecommunication system as defined by claim 10, wherein the stationary unit includes a connection for a line-conducted transmission.

13. The telecommunication system as defined by claim 10, further comprising a master station coupled to the stationary unit, the stationary unit and the master station forming a cellular system.

14. The telecommunication system as defined by claim 10, wherein the stationary unit has a transmission range defining a radio cell, the mobile unit being able to change over from the radio cell to another radio cell, the change of radio cells being signaled on the narrow-band radio channel.

15. The telecommunication system as defined by claim 10, wherein the mobile unit is switched between one of an off state and on state, the change of states being signaled on the narrow-band radio channel.

16. The telecommunication system as defined by claim 10, wherein a transmit and receive functionality of the mobile unit is switched off for the broadband radio channel and the switch off procedure is signaled on the narrow-band radio channel.

17. The telecommunication system as defined by claim 13, wherein the master station includes a connection for a line-conducted transmission and the cellular system includes network nodes, wherein via the connection, a line-conducted transmission of packets to selected network nodes is provided.

18. The telecommunication system as defined by claim 17, wherein the line-conducted transmission of packets is provided in accordance with an Asynchronous Transfer Mode (ATM).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,212,202 B1
DATED : April 3, 2001
INVENTOR(S) : Markus Radimirsch et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 5,
Line 23, change "cell i11" to -- 111 --.

Column 8,
Line 63, delete "first".

Signed and Sealed this

Twentieth Day of August, 2002

Attest:

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

Attesting Officer

APPENDIX C

US006243382B1

(12) United States Patent
O'Neill et al.

(10) Patent No.: US 6,243,382 B1
(45) Date of Patent: Jun. 5, 2001

(54) **INTERFACING TO SAR DEVICES IN ATM SWITCHING APPARATUS**

(75) Inventors: **Dominic Christopher O'Neill**, Denton; **Stephen Martin Elvy**, Prestwich; **Graeme Roy Smith**, Unsworth, all of (GB)

(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/957,899**

(22) Filed: **Oct. 27, 1997**

(30) **Foreign Application Priority Data**

Apr. 23, 1997 (GB) 9708186

(51) **Int. Cl.**[7] **H04L 12/54**
(52) **U.S. Cl.** **370/395**; 370/474
(58) **Field of Search** 370/474, 395–399

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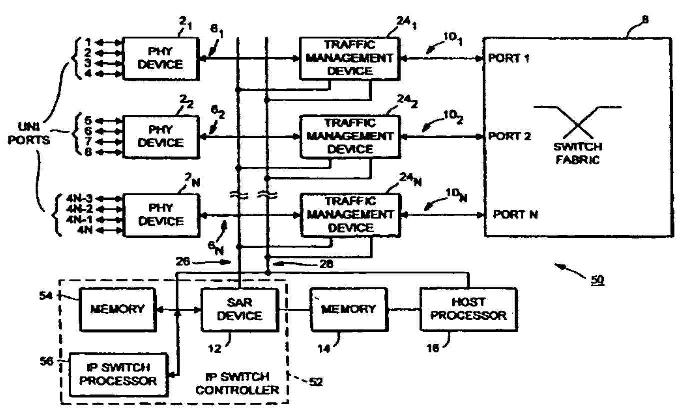
Primary Examiner—Melvin Marcelo
Assistant Examiner—Jasper Kwoh

(57) **ABSTRACT**

A switching apparatus, for use in an ATM network, includes a switch fabric for switching ATM cells, a segmentation-and-reassembly device for reassembling packets from ATM cells, and a plurality of traffic management devices. Each traffic management device receives ATM cells delivered to associated ports of the apparatus and is connected by a first data delivery path to the switch fabric and by a second data delivery path directly to the segmentation-and-reassembly device. The traffic management device identifies those received ATM cells that belong to one or more predetermined types of packets, requiring reassembly by the segmentation-and-reassembly device, as respective reassembly cells. The traffic management device then delivers received cells other than such identified reassembly cells to the switch fabric via its first data delivery path for switching by the switch fabric, and then delivers the reassembly cells to the SAR device via the second data delivery path for reassembly into packets. The reassembly cells do not pass through the switching fabric in the course of transfer from the traffic management device to the segmentation-and-reassembly device. Optionally, the segmentation-and-reassembly device is part of, or is replaced by, an internet-protocol switch controller used to detect IP flows through the switching apparatus.

28 Claims, 11 Drawing Sheets



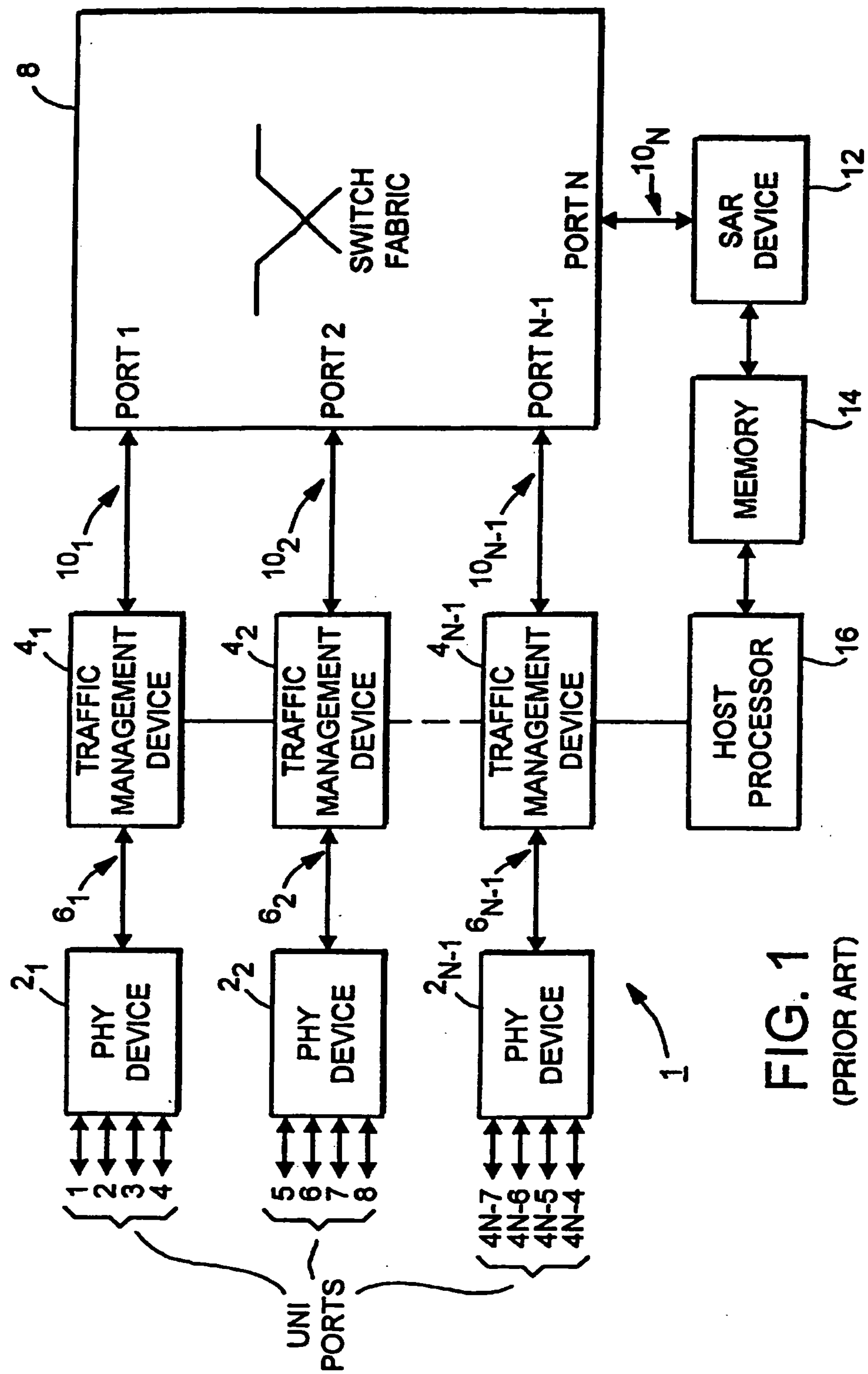


FIG. 1
(PRIOR ART)

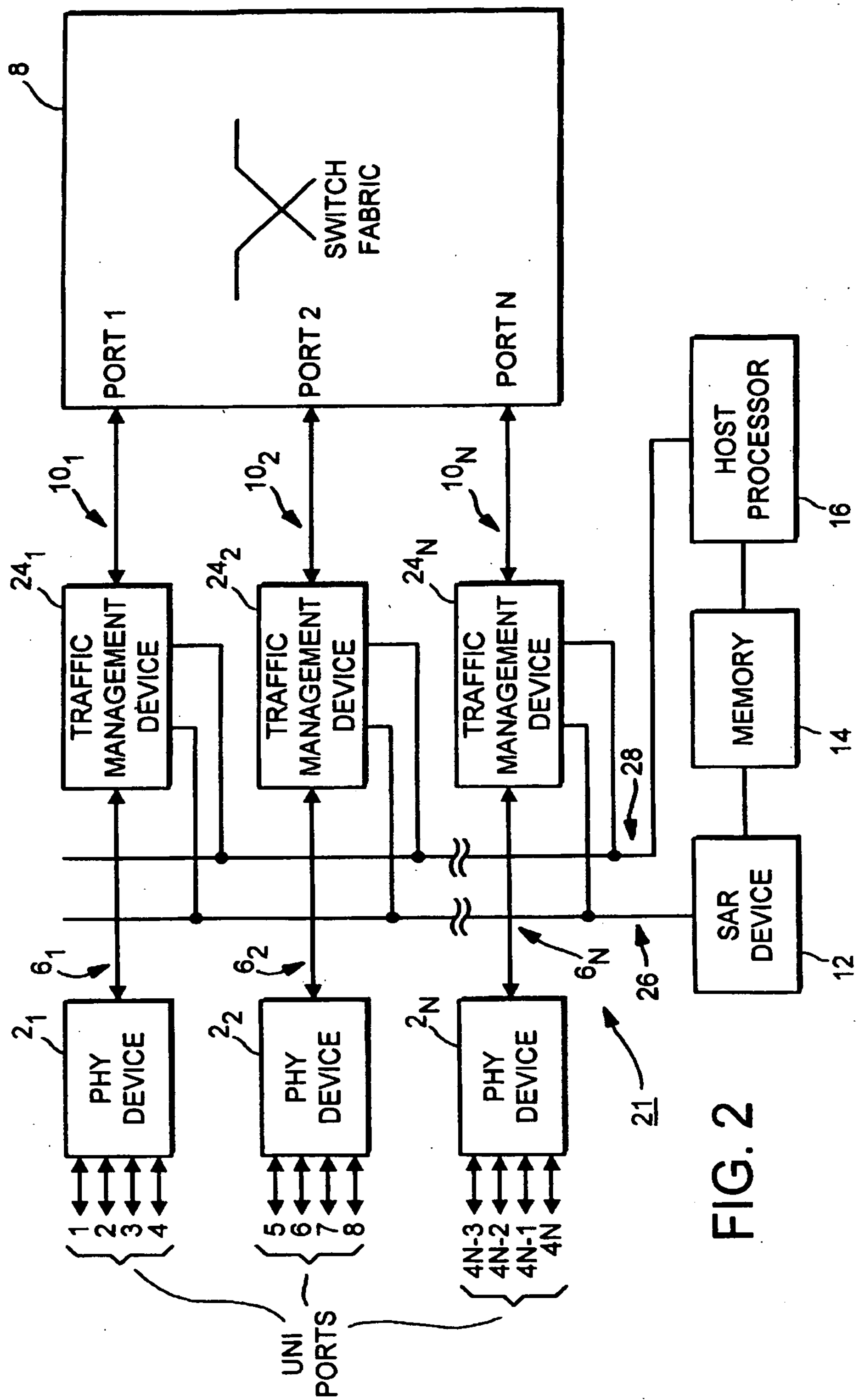

8
SWITCH FABRIC
PORT 1
PORT 2
PORT N
10_1
10_2
10_N
24_1
24_2
24_N
TRAFFIC MANAGEMENT DEVICE
TRAFFIC MANAGEMENT DEVICE
TRAFFIC MANAGEMENT DEVICE
HOST PROCESSOR
16
MEMORY
14
SAR DEVICE
12
28
26
6_1
6_2
6_N
2_1
2_2
2_N
PHY DEVICE
PHY DEVICE
PHY DEVICE
21
1 2 3 4
5 6 7 8
4N-3 4N-2 4N-1 4N
UNI PORTS

FIG. 2

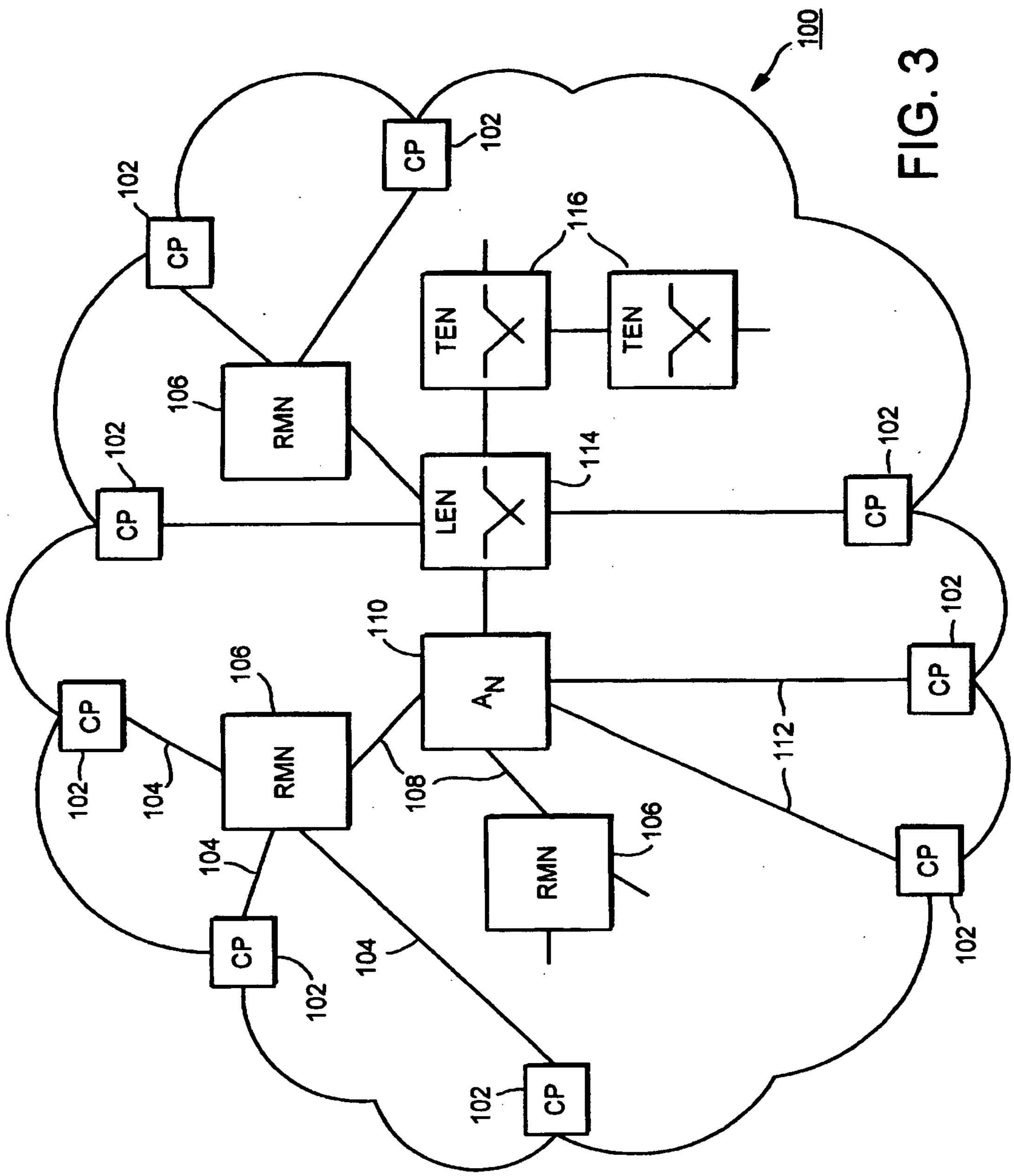


FIG. 3

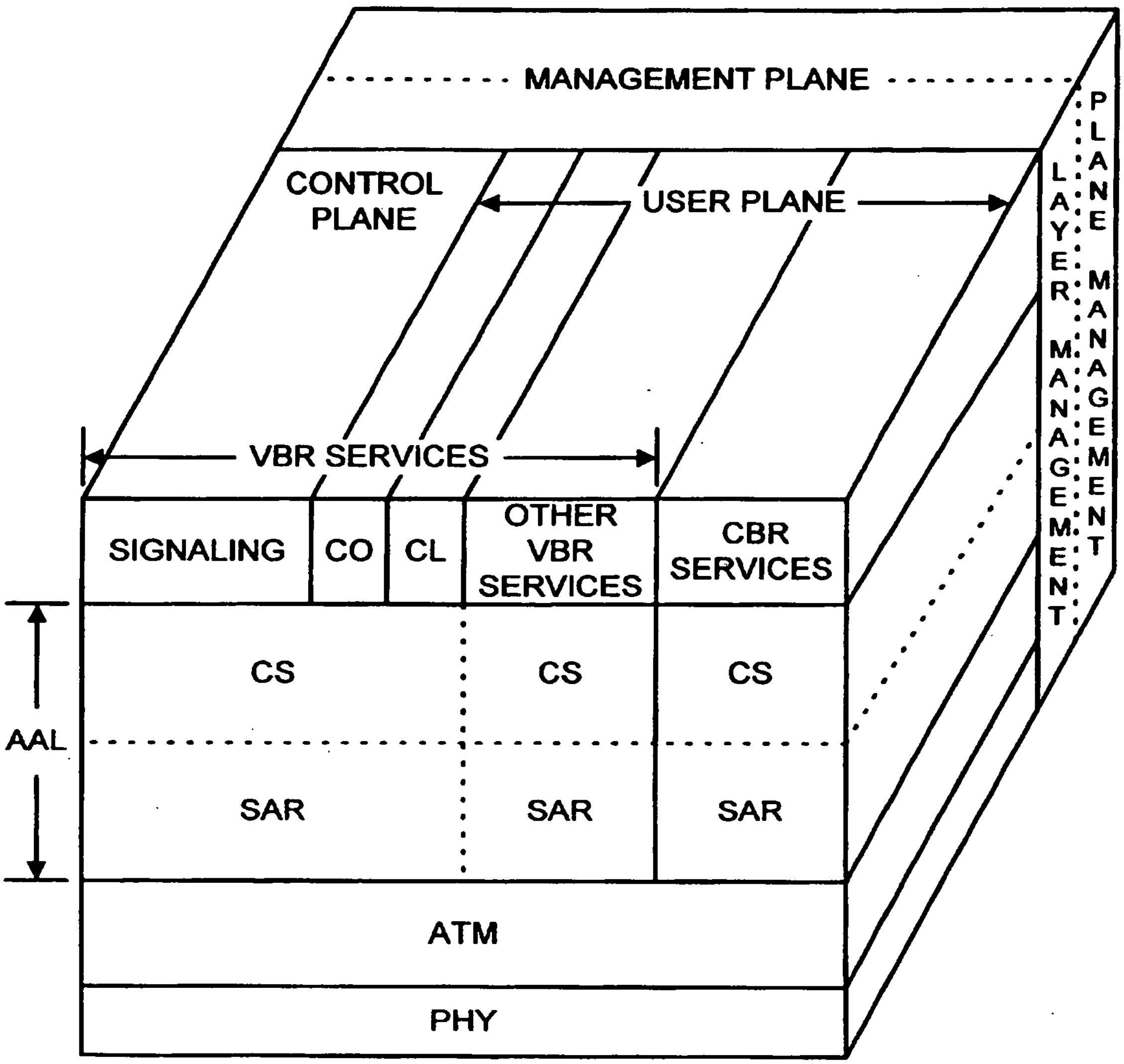

MANAGEMENT PLANE
CONTROL PLANE
USER PLANE
VBR SERVICES
SIGNALING
CO
CL
OTHER VBR SERVICES
CBR SERVICES
CS
CS
CS
AAL
SAR
SAR
SAR
ATM
PHY
LAYER MANAGEMENT
PLANE MANAGEMENT

FIG. 4

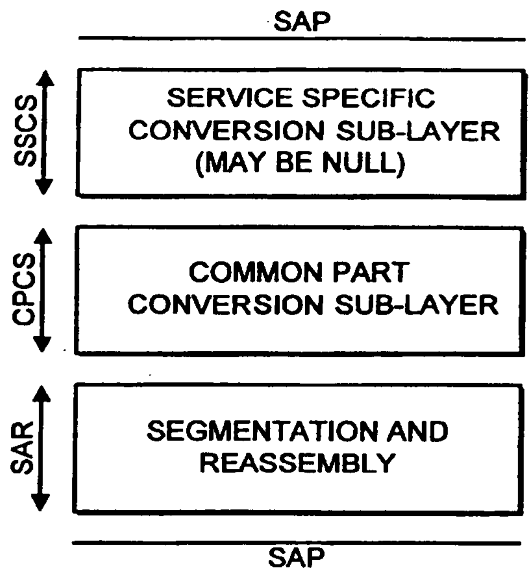

SAP
SSCS
SERVICE SPECIFIC CONVERSION SUB-LAYER (MAY BE NULL)
CPCS
COMMON PART CONVERSION SUB-LAYER
SAR
SEGMENTATION AND REASSEMBLY
SAP

FIG. 5

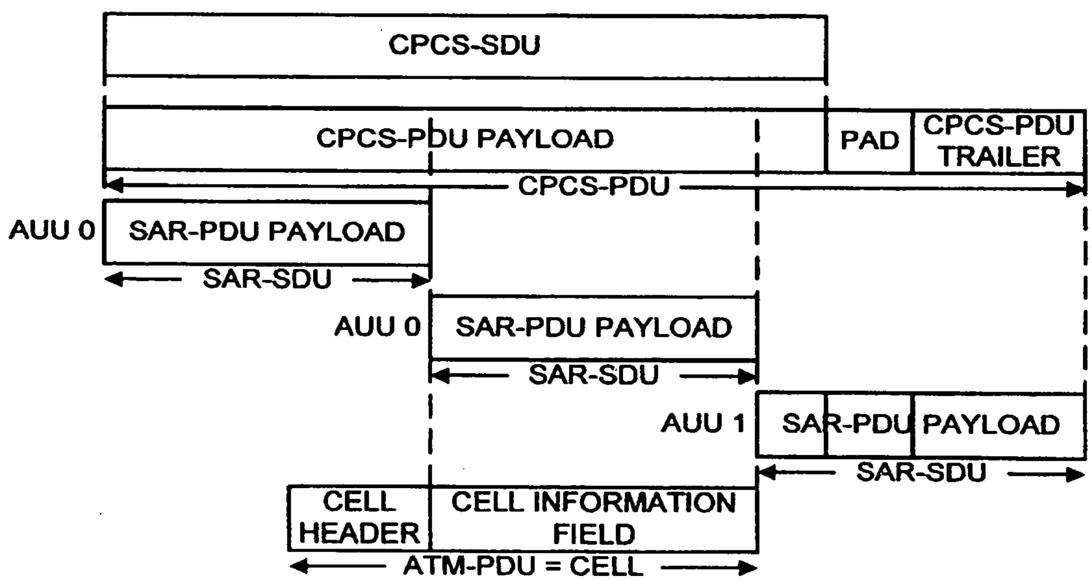
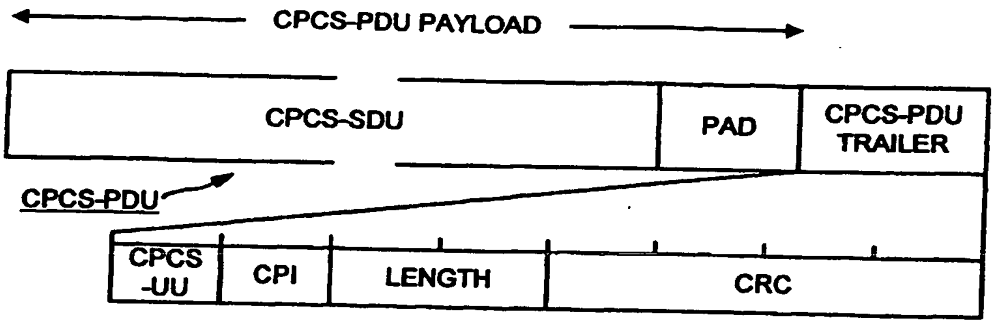
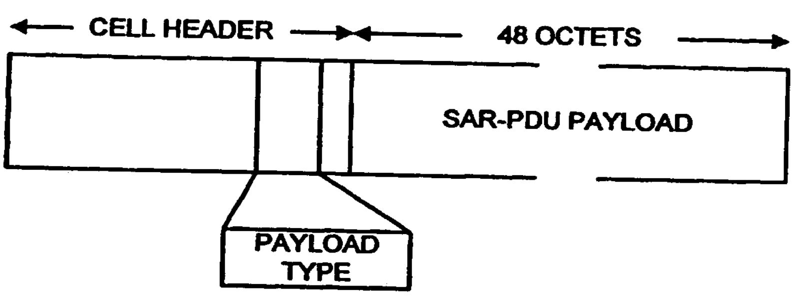

CPCS-SDU
CPCS-PDU PAYLOAD
PAD
CPCS-PDU TRAILER
CPCS-PDU
AUU 0
SAR-PDU PAYLOAD
SAR-SDU
AUU 0
SAR-PDU PAYLOAD
SAR-SDU
AUU 1
SAR-PDU PAYLOAD
SAR-SDU
CELL HEADER
CELL INFORMATION FIELD
ATM-PDU = CELL

FIG. 6



CPI:	COMMON PART INDICATOR	1 OCTET
CPCS-UU:	CPCS USER TO USER INDICATION	1 OCTET
PAD:	PADDING	0.47 OCTETS
CRC:	CYCLIC REDUNDANCY CHECK	4 OCTETS
LENGTH:	LENGTH OF CPCS-SDU	2 OCTETS

FIG. 7



PAYLOAD TYPE CODING	INTERPRETATION
000	USER DATA CELL, AUU = 0, CONGESTION NOT EXPERIENCED
001	USER DATA CELL, AUU = 1, CONGESTION NOT EXPERIENCED
010	USER DATA CELL, AUU = 0, CONGESTION EXPERIENCED
011	USER DATA CELL, AUU = 1, CONGESTION EXPERIENCED
1XX	NON USER DATA CELL

FIG. 8

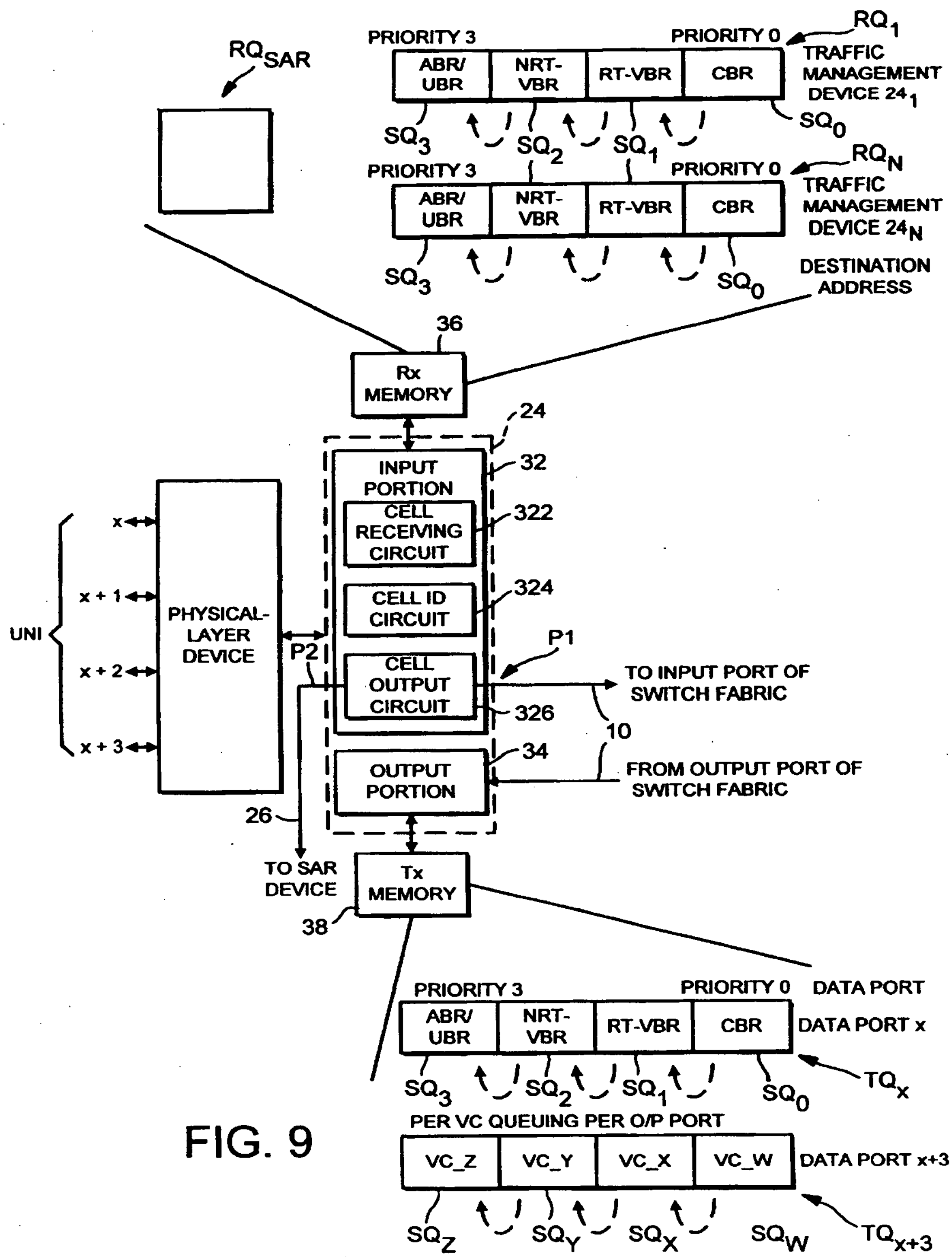

RQSAR
PRIORITY 3
PRIORITY 0
RQ1
ABR/ UBR
NRT-VBR
RT-VBR
CBR
TRAFFIC MANAGEMENT DEVICE 241
SQ3
SQ2
SQ1
SQ0
PRIORITY 3
PRIORITY 0
RQN
ABR/ UBR
NRT-VBR
RT-VBR
CBR
TRAFFIC MANAGEMENT DEVICE 24N
SQ3
SQ0
DESTINATION ADDRESS
36
Rx MEMORY
24
32
INPUT PORTION
CELL RECEIVING CIRCUIT
322
CELL ID CIRCUIT
324
CELL OUTPUT CIRCUIT
326
P1
P2
x
x + 1
x + 2
x + 3
UNI
PHYSICAL-LAYER DEVICE
TO INPUT PORT OF SWITCH FABRIC
10
34
OUTPUT PORTION
FROM OUTPUT PORT OF SWITCH FABRIC
26
TO SAR DEVICE
Tx MEMORY
38
PRIORITY 3
PRIORITY 0
DATA PORT
ABR/ UBR
NRT-VBR
RT-VBR
CBR
DATA PORT x
SQ3
SQ2
SQ1
SQ0
TQx
PER VC QUEUING PER O/P PORT
VC_Z
VC_Y
VC_X
VC_W
DATA PORT x+3
SQZ
SQY
SQX
SQW
TQx+3

FIG. 9

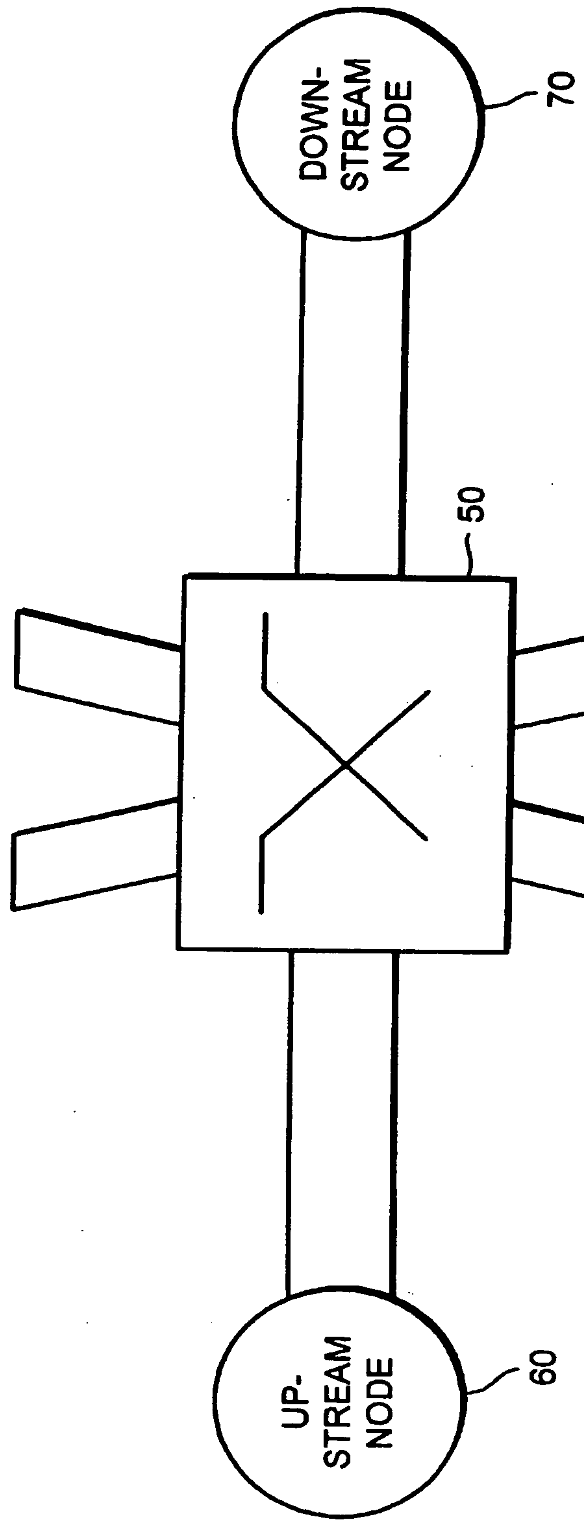


FIG. 10

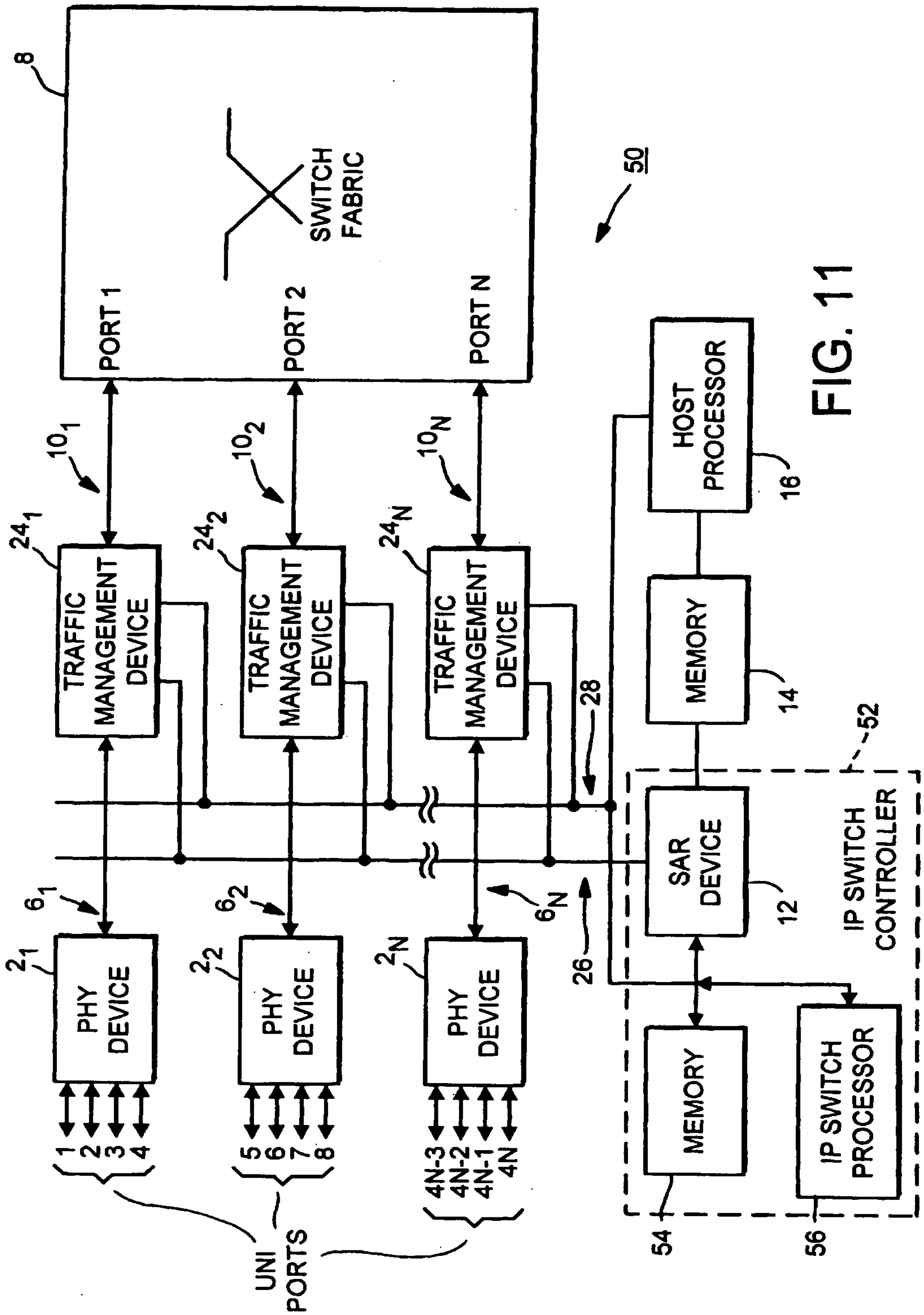

SWITCH FABRIC
PORT 1
PORT 2
PORT N
8
50
TRAFFIC MANAGEMENT DEVICE
TRAFFIC MANAGEMENT DEVICE
TRAFFIC MANAGEMENT DEVICE
HOST PROCESSOR
MEMORY
SAR DEVICE
IP SWITCH CONTROLLER
MEMORY
IP SWITCH PROCESSOR
PHY DEVICE
PHY DEVICE
PHY DEVICE
1 2 3 4
5 6 7 8
4N-3 4N-2 4N-1 4N
UNI PORTS
12
14
16
26
28
52
54
56

FIG. 11

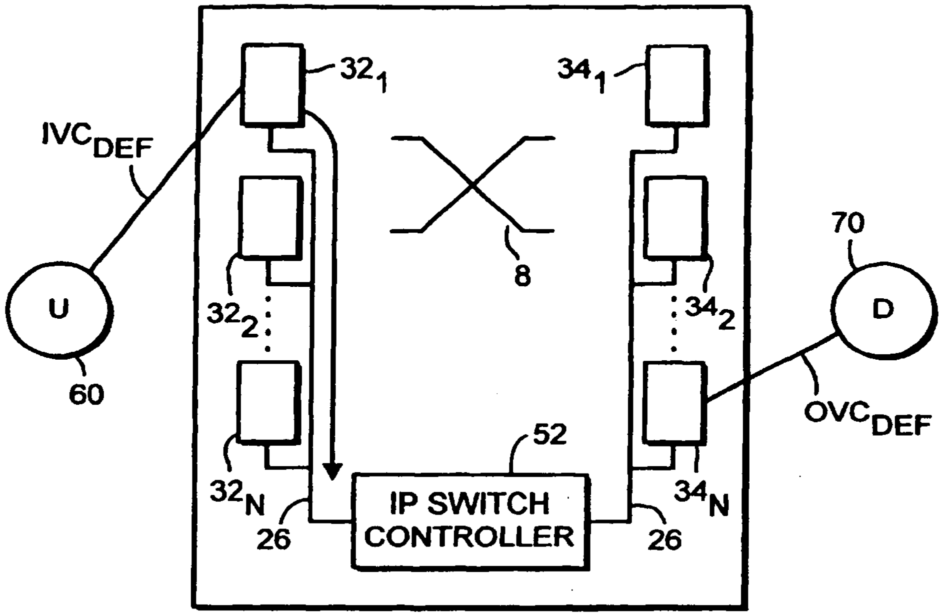


FIG. 12(A)

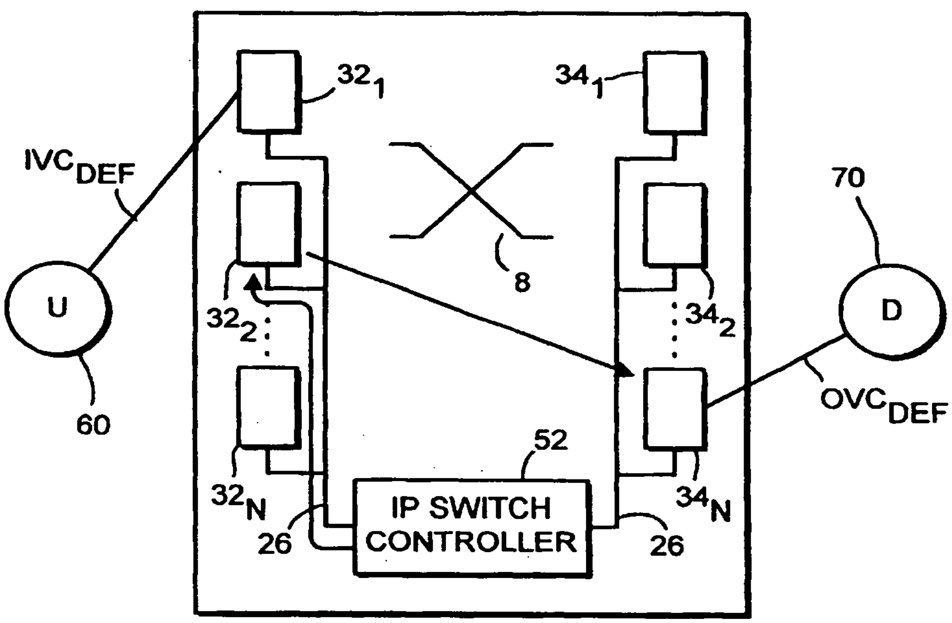


FIG. 12(B)

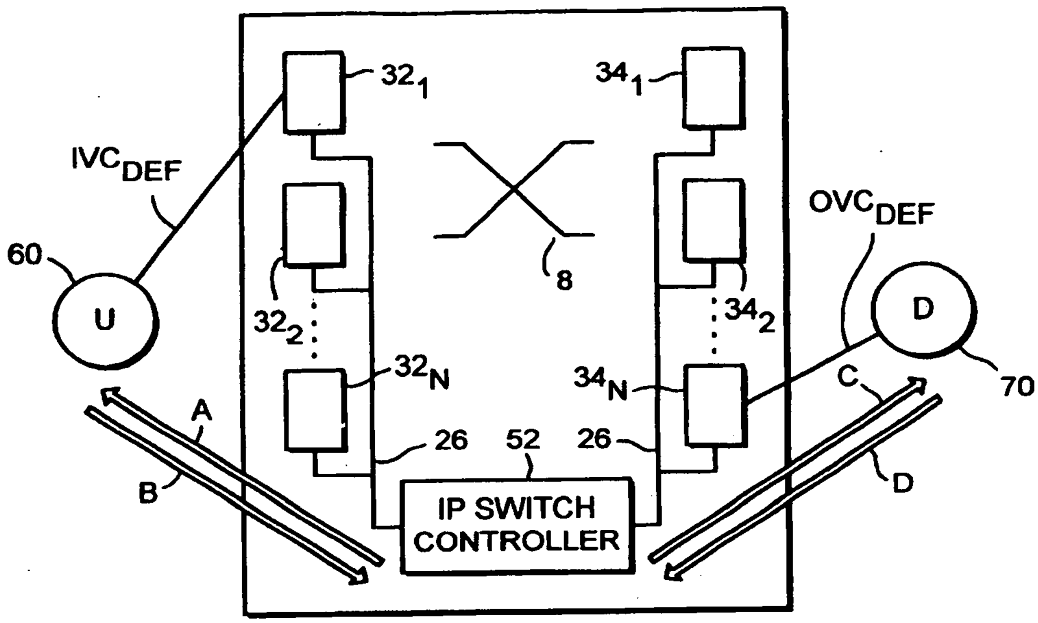


FIG. 12(C)

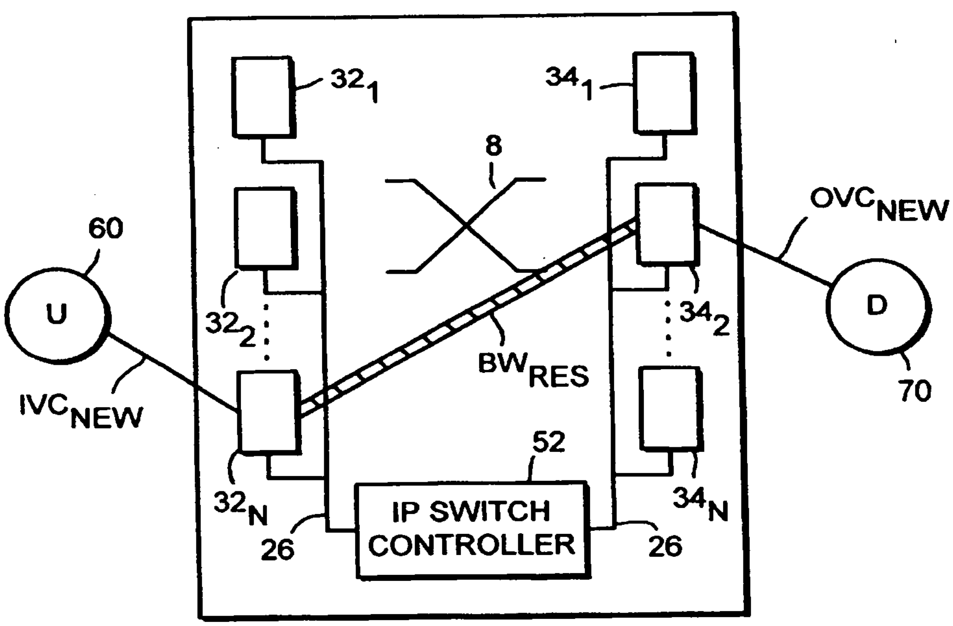


FIG. 12(D)

INTERFACING TO SAR DEVICES IN ATM SWITCHING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to interfacing to segmentation-and-reassembly (SAR) devices in asynchronous transfer mode (ATM) switching apparatus.

2. Description of the Prior Art

FIG. 1 of the accompanying drawings shows parts of conventional switching apparatus for use in an ATM communications network. The FIG. 1 apparatus comprises a plurality N-1 of physical-layer devices 2_1, 2_2, . . . 2_{N-1} and a corresponding plurality N-1 of traffic management devices 4_1, 4_2, . . . 4_{N-1}. Each traffic management device 4_i is connected to its corresponding physical-layer device 2_i by a bi-directional data delivery path 6_i.

The FIG. 1 apparatus also includes a switch fabric 8 which is, for example, a NxN cross-connect switching unit. The switch fabric 8 in fact has N input ports and N output ports. Each traffic management device 4_i is connected by a bi-directional data delivery path 10_i to a port-pair, made up of one input port and one output port. Accordingly, for the sake of simplicity, only the port-pairs are shown in FIG. 1.

The FIG. 1 apparatus also includes a segmentation-and-reassembly (SAR) device 12 which is connected to the port-pair N of the switch fabric 8 by a bi-directional data delivery path 10_N. This SAR device 12 is in turn connected to an associated memory 14. Finally, the apparatus 1 includes a host processor (or switch controller) 16 which is connected to each of the traffic management devices 4_1 to 4_{N-1} and to the memory 12.

In use of the FIG. 1 apparatus, the physical-layer devices 2_1 to 2_{N-1} provide the apparatus 1 with a plurality of bi-directional ports (user-network interface or UNI ports) which are connected to physical-layer transmission lines. These physical-layer transmission lines may be, for example synchronous digital hierarchy (SDH) or synchronous optical network (SONET) transmission lines (ITU-T standard G.709), plesiochronous digital hierarchy (PDH) transmission lines (ITU-T G.703 standard), or fibre-distributed data interface (FDDI) transmission lines (*4b/5b* standard specified by the ATM Forum). In an ATM network, these transmission lines carry ATM cells in the form of a bit stream the format of which is dependent upon the particular physical medium used to provide the transmission line concerned. In the data-receiving direction (the direction in which cells are admitted into the switching apparatus) the physical-layer devices 2_1 to 2_{N-1} convert the bit streams received at the UNI ports of the apparatus into streams of ATM cells which are delivered to the traffic management devices 4_1 to 4_{N-1} via the respective data-delivery paths 6_1 to 6_{N-1}.

The traffic management devices 4_1 to 4_{N-1} control the delivery of ATM cells to the switch fabric 8. The switch fabric 8 can provide up to N simultaneous data transfer paths, each path serving to permit transfer of data from a selected one of its input ports to a selected one of its output ports. The traffic management devices use these data transfer paths to exchange (switch) ATM cells synchronously. Overall control of the exchange process is normally performed by the host processor 16 which monitors the traffic flow conditions and selects the data transfer paths in successive time slots in order to provide a fair allocation of switch resources amongst the different cell flows passing through the apparatus.

After a traffic management device 4 receives an ATM cell through one of the data transfer paths provided by the switch fabric, it transfers that cell to its corresponding physical-layer device via the data delivery path 6. Each physical-layer device 2 converts the stream of ATM cells received thereby into bit streams suitable for transmission over the ATM transmission lines connected to the UNI ports of the physical-layer device concerned.

In an ATM network in which the FIG. 1 apparatus is used, most, but not all, of the ATM cell traffic carried is user data, whether that data represents voice signals, video signals, files, etc. However, some of the traffic carried by the network inevitably comprises control information such as signalling messages. Such signalling messages are required, for example, to establish a call. In addition, there may be a requirement for the host processors at different nodes of the ATM network (including the host processor 16 shown in FIG. 1) to communicate with one another using so-called "inter-host communication messages".

The signalling messages and inter-host communication messages are transferred across the ATM network in the form of ATM cells just like ordinary data traffic. However, the cells making up such messages are distinguished in some way from cells representing data, normally by the virtual path identifier (VPI) and virtual channel identifier (VCI) information contained in the header of each cell. The signalling messages and inter-host communication messages are generally too long to fit in the payload of a single ATM cell. Accordingly, at the source of each such message, the message is converted into a plurality of ATM cells which are then introduced successively into the network. This process is referred to as segmentation. At the destination of the message, and possibly also at any intermediate node of the ATM network at which it is desired to have access to the message concerned, the ATM cells making up the message are combined, in a process referred to as reassembly, to reproduce the original message. In the switching apparatus shown in FIG. 1, these segmentation and reassembly processes are carried out by the segmentation-and-reassembly (SAR) device 12 which is conventionally provided with its own dedicated port-pair (port N in FIG. 1) of the switch fabric 8. Thus, when the host processor 16 is informed that an ATM cell, whose VPI/VCI fields indicate that it belongs to a signalling message or an inter-host communications message, has been received by one of the traffic management devices 4 (the "source" traffic management device), the host processor 16 causes a data transfer path to be established from the input port of the switch fabric 8 to which the source traffic management device is connected (for example, input port 1 in the case of the traffic management device 4_1) to the output port N of the switch fabric 8 so that the cell concerned can be delivered from the source traffic management device to the SAR device 12. The SAR device 12 then combines that cell with other cells belonging to the same message, using the memory 14, and, once the reassembly process for that message is complete, the message can be read by the host processor 16.

If the host processor 16 is the source of a signalling message or inter-host communication message it delivers that message to the memory 14 and the SAR device 12 then segments the message to produce a plurality of ATM cells. These cells are then transferred successively to one of the traffic management devices (the "destination" traffic management device), which is the traffic management device whose corresponding physical-layer device is connected to the transmission line through which the cells must be routed to reach the destination of the message. Under the control of

the host processor 16, a data transfer path is provided for each successive cell of the message from the input port N of the switch fabric 8 to the output port of the switch fabric to which the destination traffic management device is connected. After reaching that destination traffic management device 4 the cells are then passed via the data delivery path 6 to the corresponding physical-layer device 2 and are output to the required transmission line through one of the UNI ports for onward transmission to the destination of the message.

In the FIG. 1 apparatus, the SAR device 12 is provided with its own dedicated port-pair (port N) on the switch fabric and the signalling messages and inter-host communication messages accordingly all pass through the switch fabric 8. Although the number of ATM cells involved in such messages is relatively small, as compared to the total number of ATM cells passing through the switch fabric, the need to pass the ATM cells making up the signalling and inter-host communication messages through the switch fabric inevitably leads to congestion in the switch fabric and reduces the number of opportunities to switch ATM cells representing user data. Furthermore, because one of the port-pairs of the switch fabric must be dedicated to the SAR device 12, the number of port-pairs available for connection to the traffic management devices is reduced by one. This ultimately limits the number of UNI ports of the switching apparatus as a whole.

BRIEF SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided switching apparatus, for use in an ATM network, including: a switch fabric for switching ATM cells; reassembly means for reassembling packets from ATM cells; and traffic management means connected for receiving ATM cells delivered to the apparatus and also connected by first data delivery path means to the said switch fabric and by second data delivery path means, separate from the first data delivery path means, to the said reassembly means, and operable to identify those received ATM cells that belong to one or more predetermined types of packet, requiring reassembly by the reassembly means, as respective reassembly cells, and to deliver received cells other than such identified reassembly cells to the switch fabric via the said first data delivery path means for switching by the said switch fabric and to deliver the said reassembly cells to the said reassembly means via the said second data delivery path means for reassembly into packets by the reassembly means.

According to a second aspect of the present invention there is provided a traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having reassembly means for reassembling packets from ATM cells delivered to the apparatus, which device includes: cell receiving means for receiving ATM cells; cell identification means connected to the said cell receiving means and operable to identify as respective reassembly cells those received cells that belong to one or more predetermined types of packet requiring reassembly by the said reassembly means of the apparatus; and cell output means having first port means adapted for connection, when the device is in use, to the said switch fabric, and also having second port means, separate from the said first port means, adapted for connection when the device is in use to the said reassembly means, and operable to deliver received cells other than the identified reassembly cells to the said first port means and to deliver the said reassembly cells to the said second port means.

According to a third aspect of the present invention there is provided a switching method, for use in ATM-network switching apparatus that includes a switch fabric for switching ATM cells, reassembly means for reassembling packets from ATM cells, and traffic management means for receiving ATM cells delivered to the apparatus, in which method: those received ATM cells that belong to one or more predetermined types of packet, requiring reassembly by the reassembly means, are identified by the traffic management means as respective reassembly cells; received cells other than such identified reassembly cells are delivered by the traffic management means to the switch fabric via first data delivery path means and are switched by the switch fabric; and the identified reassembly cells are delivered from the traffic management means to the reassembly means via second data delivery path means separate from the first data delivery path means, and are reassembled into packets by the reassembly means.

In the first to third aspects of the present invention the cells requiring reassembly can be sent directly to the reassembly means without passing through the switch fabric. Accordingly, all of the switch ports of the switch fabric are available for use by the traffic management means to switch the non-reassembly cells. Switch throughput is therefore increased and contention problems in the switching apparatus are alleviated.

Packets requiring reassembly may be, for example, signalling messages (in particular AAL5 messages) or inter-host communication messages (in particular Interim Local Management Interface (ILMI) communications between ATM user-network interface (UNI) management entities).

Packets requiring reassembly may also include internet-protocol packets. In this case, the apparatus preferably further includes internet-protocol switch controller means connected with the said reassembly means for examining such reassembled internet-protocol packets to detect packet flows through the switching apparatus. The traffic management means can then send cells needed by the internet-protocol switch controller means directly thereto without those cells passing through the switch fabric.

Preferably, the traffic management means are operable, in a default routing mode thereof, to receive such internet-protocol packets from an upstream node of the ATM network via a predetermined default input virtual channel and to identify, as such reassembly cells, received ATM cells belonging to the said predetermined default input virtual channel and to deliver those cells via the said second data delivery path means to the said reassembly means so as to permit the said internet-protocol switch controller means to detect packet flows from examination of the reassembled packets. The traffic management means are also switchable, upon detection by the said internet-protocol switch controller means of such a packet flow, to operate in an cut-through switching mode in which the cells of subsequent packets making up the detected packet flow are received by the traffic management means via a new input virtual channel, different from the said predetermined default input virtual channel, and are not identified as such reassembly cells and are delivered directly to the switch fabric via the said first data delivery path means.

In this way, cells belonging to detected flows can be routed through the switching apparatus without being reassembled in the switching apparatus by the internet-protocol switch controller means, so as to implement so-called cut-through switching in which the cells of flows are routed directly in hardware. For example, upon detection by the

said internet-protocol switch controller means of such a packet flow, the traffic management means may be caused to reserve bandwidth for switching the cells of the detected packet flow via the said switch fabric.

Preferably, reassembled packets not detected by the said internet-protocol switch controller means as belonging to a packet flow are segmented into a plurality of cells which are transferred back to the traffic management means for delivery to the said switch fabric, so as to implement store-and-forward routing of the IP packets that do not belong to flows. After passage through the said switch fabric, the cells of the said plurality may then be output to a downstream node of the ATM network via a predetermined default output virtual channel. On the other hand, during operation of the traffic management means in the said cut-through switching mode, the cells of the said subsequent packets making up the detected packet flow are preferably output by the traffic management means via a new output virtual channel, different from the said predetermined default output virtual channel.

In one embodiment, the said traffic management means include cell identification means operable to examine the virtual-path-identifier and/or virtual-channel-identifier fields of the header of each received ATM cell and to determine, in dependence upon the results of such examination, whether or not the cell concerned is to be identified as such a reassembly cell. This makes it possible to identify the reassembly cells quickly and easily.

Preferably, the apparatus further includes segmentation means (the segmentation means and the reassembly means may form part of the same segmentation-and-reassembly device), which segmentation means are also connected to the said traffic management means by the said second data delivery path means, and are operable to segment a packet generated locally in the apparatus into a plurality of ATM cells and to deliver the cells of the said plurality to the traffic management means via the said second data delivery path means. In this arrangement the cells resulting from segmentation can also be delivered to the traffic management means without passing through the switch fabric.

In this case, the second data delivery path means may include respective unidirectional transmit and receive path means, the receive path means serving to deliver the identified reassembly cells from the traffic management means to the reassembly means, and the transmit path means serving to deliver the cells of the said plurality from the said segmentation means to the traffic management means.

In a preferred embodiment, the said traffic management means include a plurality of individual traffic management devices connected respectively to the said switch fabric by the said first data delivery path means for exchanging ATM cells via data transfer paths provided by the switch fabric, and the said second data delivery path means comprise bus means (for example Universal-Test-and-Operations- PHY-Interface-for-ATM (UTOPIA) level 2 "lookalike" bus means) connecting the individual traffic management devices in common to the reassembly means and, if provided, to the said segmentation means. In this arrangement, each traffic management device controls the delivery of cells to one or more associated input ports of the switch fabric, and each traffic management device can send any reassembly cells directly to the reassembly means using the bus means.

To enable the different traffic management devices to share the bus means, it is preferable that the said reassembly means are operable as a master device of the said bus means and each traffic management device is operable as a slave device of the said bus means. In this case, for example, the said reassembly means include: polling means for polling the traffic management devices to determine if any of them has identified a received ATM cell as being such a reassembly cell; and data reading means operable, if it is determined by the said polling means that one of the said traffic management devices has identified such a reassembly cell, to cause the traffic management device having that cell to deliver it to the reassembly means via the said bus means.

According to a fourth aspect of the present invention there is provided switching apparatus, for use in an ATM network, including: a switch fabric for switching ATM cells; segmentation means for segmenting a packet generated locally in the apparatus into a plurality of ATM cells; and traffic management means connected by first data delivery path means to the said switch fabric and by second data delivery path means, separate from the said first data delivery path means, to the said segmentation means, and operable to receive from the switch fabric via the said first data delivery path means cells that have been switched by the switch fabric and to receive from the segmentation means via the said second data delivery path means the cells of the said plurality, and to output an ATM cell stream including the switched cells received from the switch fabric and the cells of the said plurality received from the segmentation means.

According to a fifth aspect of the present invention there is provided a traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having segmentation means for segmenting packets generated locally by the apparatus into a plurality of ATM cells to be output from the apparatus, which device includes: cell input means having first port means adapted for connection, when the device is in use, to the said switch fabric, and also having second port means, separate from the said first port means, adapted for connection when the device is in use to the said segmentation means, and operable to receive at the said first port means cells that have been switched by the switch fabric and to receive at the said second port means the cells of the said plurality; and cell output means for outputting an ATM cell stream including the switched cells received from the switch fabric and also including the cells of the said plurality.

According to a sixth aspect of the present invention there is provided a switching method, for use in ATM-network switching apparatus that includes a switch fabric for switching ATM cells, segmentation means for segmenting a packet generated locally in the apparatus into a plurality of ATM cells, and traffic management means for outputting switched cells, in which method: cells that have been switched by the switch fabric are received by the traffic management means from the switch fabric via first data delivery path means; the plurality of cells produced by the segmentation means are received by the traffic management means via second data delivery path means separate from the said first data delivery path means; and an ATM cell stream, including the switched cells received from the switch fabric and the cells of the said plurality received from the segmentation means, is output by the traffic management means.

In the fourth to sixth aspects of the invention, advantages corresponding to the advantages achieved by the first to third aspects of the invention can be obtained even when the switching apparatus has no reassembly means. The cells resulting from segmentation can be transferred directly to the traffic management means without passing through the switch fabric, freeing up the switch ports of the switch fabric for non-segmentation cells and alleviating congestion.

According to a seventh aspect of the present invention there is provided switching apparatus, for use in an ATM network, including: a switch fabric for switching ATM cells; internet-protocol switch controller means for detecting internet-protocol flows through the switching apparatus; and traffic management means connected for receiving ATM cells delivered to the apparatus and also connected by first data delivery path means to the said switch fabric and by second data delivery path means, separate from the first data delivery path means, to the said internet-protocol switch controller means, and operable, in a default routing mode thereof, to identify, as default-routing cells, those received ATM cells belonging to a predetermined default input virtual channel and to deliver those cells via the said second data delivery path means to the said internet-protocol switch controller means so as to permit the said internet-protocol switch controller means to detect such flows from examination of the delivered cells, and being switchable, upon detection by the said internet-protocol switch controller means of such a flow, to operate in a cut-through switching mode in which the subsequently-received cells making up the detected flow are received by the traffic management means via a new input virtual channel, different from the said predetermined default input virtual channel, and are not identified as such default-routing cells and are delivered directly to the switch fabric via the said first data delivery path means.

According to an eighth aspect of the present invention there is provided a traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having internet-protocol switch controller means for detecting internet-protocol flows through the switching apparatus, which device includes: cell receiving means for receiving ATM cells; cell output means having first port means adapted for connection, when the device is in use, to the said switch fabric, and also having second port means, separate from the said first port means, adapted for connection when the device is in use to the said internet-protocol switch controller means; and cell identification means connected to the said cell receiving means and operable, in a default routing mode thereof, to identify, as default-routing cells, those received ATM cells belonging to a predetermined default input virtual channel and to deliver those cells to the said second port means for transfer to the said internet-protocol switch controller means so as to permit the said internet-protocol switch controller means to detect such flows from examination of the delivered cells, and being switchable, upon detection by the said internet-protocol switch controller means of such a flow, to operate in a cut-through switching mode in which the subsequently-received cells making up the detected flow are received by the traffic management device via a new input virtual channel, different from the said predetermined default input virtual channel, and are not identified as such default-routing cells and are delivered to the first port means for transfer directly to the switch fabric.

In the seventh and eighth aspects of the invention it is not necessary that the internet-protocol switch controller means have reassembly means for reassembling the identified default-routing cells received from the traffic management means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1, discussed hereinbefore, shows parts of switching apparatus previously considered for use in an ATM network;

FIG. 2 shows parts of ATM switching apparatus according to a first embodiment of the present invention;

FIG. 3 shows in schematic form a broadband integrated services digital network (B-ISDN) in which the FIG. 2 apparatus may be used;

FIG. 4 shows a layer model for use in explaining communications protocols used in the FIG. 3 network;

FIG. 5 shows in more detail than in FIG. 4 an ATM adaptation layer (AAL) shown in the FIG. 4 model;

FIG. 6 is a schematic diagram for use in explaining segmentation and reassembly processes in accordance with one type of AAL;

FIG. 7 shows in more detail than in FIG. 6 one of the data entities employed in the segmentation and reassembly processes of FIG. 6;

FIG. 8 shows the format of a ATM cell employed in the FIG. 6 segmentation and reassembly processes; and

FIG. 9 shows a schematic view of a traffic management device employed in the FIG. 2 switching apparatus, for use in explaining operation of the apparatus;

FIG. 10 shows a block diagram showing parts of an ATM network including switching apparatus according to a second embodiment of the present invention;

FIG. 11 shows parts of ATM switching apparatus according to the second embodiment of the present invention; and

FIGS. 12(A) to 12(D) are schematic diagrams for use in explaining operation of the FIG. 11 apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 shows parts of ATM switching apparatus embodying the present invention. In FIG. 2, parts which correspond to parts already described before with reference to FIG. 1 will be denoted by the same reference numerals.

In the FIG. 2 switching apparatus 21, each traffic management device 24_1 to 24_N is modified as compared to the traffic management devices 4_1 to 4_{N-1} described hereinbefore with reference to FIG. 1. As in the FIG. 1 apparatus, each traffic management device 24_i is connected to its corresponding physical-layer device 2_i by way of a data delivery path 6_i (i=1 to N). Each data delivery path 6_i is a Universal Test and Operations PHY interface (UTOPIA) level 2 path providing in each direction a 16 bit data path for data transfer at up to 622 Mbps (clock frequency ≦50 MHz). Each physical-layer device 2 and each traffic management device 4 therefore has two ports (one for transmitting and the other for receiving), and both ports use the same protocol and interface definition.

Although for simplicity only one physical-layer device 2_i is shown connected to each traffic management device 24_i in FIG. 2, the UTOPIA level 2 path 6_i can in fact permit connection of up to n physical-layer devices to each traffic management device, where n≦8 in the case in which the ATM layer operates at 155 Mbps and n≦4 in the case in which the ATM layer operates at 622 Mbps. The UTOPIA level 2 interface includes five addressing lines, thereby providing a virtual space for up to 31 ports on up to 8 physical-layer devices.

A more complete description of the UTOPIA Level 2 interface can be found in "UTOPIA", An ATM-PHY Interface Specification, Level 2, Version 1.0", June 1995, published by the ATM Forum.

Each traffic management device 24_i is also connected by a data delivery path 10_i to a port-pair of the switch fabric 8, which port-pair is made up of an input port and an output port. The data delivery path 10_i can be of any suitable type,

parallel or serial, but in the present embodiment the interface for the data delivery path 10_i provided at the traffic management device 24_i is a UTOPIA level 2 "lookalike" (UL2LAL) interface. This has basically the same characteristics as the above-mentioned UTOPIA level 2 standard interface promulgated by the ATM Forum but is described as being a "lookalike" interface to that standard interface because the UTOPIA standard interface is intended to connect ATM-layer devices (such as the traffic management devices) to physical-layer devices, and not to provide connections between two ATM-layer devices such as the traffic management device and the switch fabric.

It is also possible for the data delivery path 10_i to contain a parallel/serial converter so that the path is parallel at the end connected to the traffic management device 24_i and serial at the end connected to the switch fabric. This can enable the number of connection pins on the switch fabric 8 to be reduced, as described in the present assignee's copending United Kingdom Patent Application No. 9617110.3 and U.S. patent application No. 08/869,762. Alternatively, or in addition, plural traffic management devices may be connected to the same port-pair on a time-division-multiplexing basis, again so as to reduce the number of connection pins required on the switch fabric 8, as also described in the present assignee's copending United Kingdom Patent Application No. 9617110.3 and U.S. patent application No. 08/869,762. The contents of that application, and of the present assignee's further copending United Kingdom Patent Application No. 9617100.4 and U.S. patent application No. 08/866,252, are incorporated herein by reference.

Each traffic management device 24_i is also connected to the host processor 16 by way of a host bus 28. The host bus is, for example, a bidirectional 32-bit-wide data path with address lines sufficient in number to address (poll) individually the N different traffic management devices 24_1 to 24_N.

The switching apparatus 21 shown in FIG. 2 differs from the switching apparatus 1 shown in FIG. 1 primarily by virtue of the fact that a further bus 26, referred to hereinafter as the SAR bus, is provided to connect each traffic management device 24_1 to 24_N to the segmentation-and-reassembly (SAR) device 12. Accordingly, unlike in the FIG. 1 switching apparatus, the SAR device 12 is not connected to one of the port-pairs of the switch fabric 8. The SAR bus 26 is preferably a half-width (8-bit data in each direction) UL2LAL interface. In this case, the SAR device 12 is the master device, which has control over the SAR bus 26, and each traffic management device 24_1 to 24_N is a slave device. Alternatively, the SAR bus 26 could be a high-speed serial bus so as to reduce the pin count of the traffic management devices 24 and SAR device 12. The second bus may be used to transfer Low Voltage Differential Signals (LVDS).

The SAR device 12 may be, for example, type MB86687A manufactured by the present assignees.

Operation of the FIG. 2 apparatus will now be described. Before describing the detailed operation of the apparatus, however, a brief overview will be given with reference to FIG. 3 of a broadband integrated services digital network (B-ISDN) in which the FIG. 2 switching apparatus may be used. It will be understood that the FIG. 2 switching apparatus is not limited to being used in a B-ISDN, but the B-ISDN serves to provide a useful example for the purposes of explanation since it involves connection-oriented communication protocols that give rise to large numbers of signalling messages (and inter-host communication messages) of the kind which embodiments of the present invention are intended to deal effectively with. However, all communications protocols used in ATM networks, even connectionless protocols, inevitably involve the generation and processing of signalling messages, and embodiments of the present invention are applicable advantageously to all such networks.

The B-ISDN network 100 shown in FIG. 3 has a plurality of customer premises (CP) nodes 102 corresponding respectively to different customer premises. At each CP node arbitrarily-formatted information supplied by the user is converted into an ATM cell stream, and, in the reverse direction, an ATM cell stream received from the network is converted into user information in the required format. These conversions are performed by an ATM adaptation layer (AAL) in the CP node which serves the function of a terminal adaptor. CP nodes which only generate and receive low-bandwidth ATM cell streams are normally connected by fixed-point transmission facilities to a remote multiplexer node (RMN) 106 at which the individual low-bandwidth ATM cell streams are statistically multiplexed into/demultiplexed from a concentrated link 108. Several such concentrated links 108 are connected to an access node (AN) 110 to which higher-bandwidth CP nodes 102 may also be connected by links 112. A highly-multiplexed ATM cell stream emerging from the access node 110 is carried to a local exchange node (LEN) 114 to which other RMNs 106 and even very-high-bandwidth CP nodes 102 may also be connected. The FIG. 2 switching apparatus may, for example be used in the LEN 114. The LEN 114 is connected to a tandem exchange node (TEN) 116 which is a larger ATM switch than the LEN 114. Again, the FIG. 2 switching apparatus may be used in the TEN 116.

The B-ISDN network 100 shown in FIG. 3 is a connection-oriented network which requires connection-oriented communication protocols. Connection-oriented protocols require a call setup procedure, even though the information flows between different CP nodes are in the form of ATM cells with header fields containing the routing information. The call setup procedure selects a path or route to be used by all ATM cells associated with a connection, and the traffic intensity appearing on each physical link of the network, for example the links 108 in FIG. 3, is controlled by limiting the number of connections sharing that link. The paths are selected so as to spread the total applied loads fairly among all of the network links and packet switching nodes (for example the LEN 114 and TEN 116), the intention being to avoid congestion.

If a new connection is admitted, a "virtual connection" number (i.e. particular virtual path identifier (VPI) and virtual channel identifier (VCI) values) is assigned to that connection, and appears in the VPI/VCI fields of all ATM cells belonging to that connection. The virtual connection number implicitly identifies both the source and destination for each packet upon call establishment. Each switch along the selected path is informed, using signalling messages, of the assigned virtual connection number, and is provided with routing instructions to be followed whenever an ATM cell containing that virtual connection number arrives.

The connection-oriented communication protocols are implemented by a call processing function. This function is generally the shared responsibility of processors attached to the geographically-distributed CP nodes but for the purposes of explanation it is possible to regard the call processing function as being implemented as a single centralised processor. Each CP node has a permanent virtual channel number assigned to it for communication with the centralised call processor, and the centralised call processor is connected to the transport network through an ordinary CP

node and therefore appears to the transport network like any other user or application. A user at a particular CP node ("source" CP node) may use the permanent virtual connection from that CP node to the call processor to request a connection to another desired CP node ("destination" CP node). The requested connection may be two-way to enable full duplex operation. The call processor uses a permanent virtual connection from itself to the destination CP node to ask the destination CP node if it wishes to accept the requested connection. If so, the call processor attempts to find a path which, when loaded with the requested new virtual connection, will still enable the quality of service currently enjoyed by each other connection already using that path to be maintained at above the guaranteed minimum level.

If the destination CP node refuses to accept the connection, or if a suitable path cannot be found, the connection is blocked and the source CP node is informed of this using a signalling message sent via the permanent virtual connection from the call processor to the source CP node. If, on the other hand, the connection can be established, all switching nodes along the selected path are informed by the processor of the new virtual connection number, and are provided with appropriate routing instructions. For this purpose, signalling messages are sent from the call processor to the affected switching nodes via permanent virtual connections. These signalling messages are required to be delivered to the host processor in the switching node, for example the host processor **16** in the FIG. **2** switching apparatus. The way in which the signalling messages are handled within the FIG. 2 apparatus itself will be considered in more detail later on.

Incidentally, in addition to permanent (pre-configured) virtual connections, switched (dial-up connectivity) virtual connections can also be used to carry signalling messages.

Once the call has been established, the source and destination CP nodes exchange information over the assigned path (or paths, in the case of a duplex connection). Each ATM cell passing along the assigned path(s) contains the assigned virtual connection number in its header, and only the header is processed (in real time, preferably using VLSI circuitry wherever possible) by the switching nodes to make the required routing decision. Accordingly, all cells associated with a given virtual connection follow the same route through the network and are delivered in the same sequence in which they were generated.

When either the source or destination CP node wishes to end the call, a process similar to call establishment is used to effect call release. Again, permanent virtual connections are used to send signalling messages between the source and destination CP nodes and the call processor, and between the call processor and the affected switching nodes.

In the FIG. 3 network, just as user information is transported in the form of ATM cells, the signalling messages between the source and destination CP nodes and between the call processor and the switching nodes are also sent in the form of ATM cells. The conversion of user information and signalling messages into ATM cells is the function of the ATM adaptation layer (AAL).

Referring to FIG. 4, which shows the protocols relevant to the operation of one of the CP nodes shown in FIG. 3, the ATM adaptation layer for the CP node may need to support several types of services. User services include connection-oriented, connectionless and possibly other types of variable bit rate (VBR) services, and constant bit rate (CBR) services. VBR services support non-persistent types of traffic having various different peak data rates, for example bursty data traffic, image files, large database file transfer, packet video and packet voice. CBR services, on the other hand, support persistent types of traffic that have a constant data rate over a prolonged period, for example digital video and 64 k bit/s digital voice. Control signals (signalling messages) are provided as yet another VBR service.

The AAL has a user interface at which it receives user-generated information signals, and a control interface at which it receives control signals. The AAL serves to convert the information and control signals into a standard format suitable for ATM prior to introducing these signals into the ATM network, and to reconstruct the information signals and control signals from ATM cells arriving from the network prior to outputting them to the user and control interfaces.

The AAL is in turn divided into two sub-layers as shown in FIG. 4. The conversion sub-layer (CS) performs an encapsulation/de-encapsulation function for the user-generated signals and control signals. In fact, as shown in FIG. 5, in certain types of AAL, for example AAL3/4 and AAL5, the CS sub-layer has been further subdivided into a common part conversion sub-layer (CPCS) and a service specific conversion sub-layer (SSCS). A number of SSCS protocols have been defined, or are currently under development, to support specific AAL user services. AAL5 is generally used for signalling messages.

As shown in FIG. **6**, which relates to AAL5, at a source CP node an original user-generated information signal, or a control signal, to be transported through the ATM network and ultimately to be delivered to the destination CP node is delivered (after processing in the SSCS, if provided) to the CPCS in the form of a CPCS service data unit (CPCS-SDU). In the CPCS the signal (CPCS-SDU) is encapsulated in a CPCS protocol data unit (CPCS-PDU) as the payload thereof, as shown in FIG. 7. The CPCS-PDU also has a padding field, which can be up to 47 octets in length, and an 8 octet trailer, the format of which is shown in more detail in FIG. 7. A CPCS-user-to-user (CPS-UU) indication field is used to transparently transfer CPCS user-to-user information. Currently, a common part indicator (CPI) is only used to indicate 64 bit alignment of the trailer and is set to 0, but possible future functions under consideration include the identification of management messages, for fault monitoring purposes etc., and the identification of operation-and-maintenance (OAM) messages. A length field simply indicates the length of the CPCS-PDU payload. The payload length can range from 1 to 65535 octets and must be octet aligned. The length field is used by the receiver to detect the loss or gain of information. The length field is binary encoded with the number of octets. A cyclic redundancy check (CRC) field is used to detect bit errors in the CPCS-PDU. The scope of the CRC covers the whole of the CPCS-PDU including the padding field, the CPCS-UU, the CPI and the length field.

Although as shown in FIG. **6** the CPCS-PDU does not have a header, a header may already have been added by a service specific conversion sub-layer (SSCS) in which case that header will accordingly form a part of the CPCS-SDU.

The whole of the CPCS-PDU is then passed to the SAR sub-layer (FIG. **4**) which treats the CPCS-PDU as a single field of variable length. As shown in FIG. **6**, the SAR function then divides the CPCS-PDU into 48-octet segments, each of which constitutes the payload of one SAR-PDU. The last segment may need padding to form a full 48-octet payload. The SAR-PDU further comprises a 5-byte header, as shown in FIG. **8**.

In the AAL5 SAR function, the main focus is efficiency, and accordingly all of the 48 octets available in an ATM cell payload are used to carry the user or control information. Accordingly, none of the octets of the SAR-PDU payload is available to indicate the beginning, continuation or end of the message. Instead, the payload type (PT) field of the ATM cell header is used by the SAR function to detect the beginning, continuation and end of messages. The usual PT information is still carried in the PT field but is encoded with an ATM-layer-user-to-ATM-layer-user (AUU) parameter to produce the payload type codings shown in FIG. 8.

This completes the segmentation process performed by the AAL5 layer. The reassembly process is essentially the reverse of the segmentation process and serves to reconstitute a message (CPCS-SDU or, if applicable, SSCS-SDU) from a plurality of SAR-SDUs.

The ATM layer in FIG. 4 is responsible for attaching/stripping the 5 byte header to/from each SAR-PDU to form the 53-octet ATM cell. The physical layer is responsible for placing the cells onto/receiving cells from the transmission link medium. Except in the case of signalling messages directed specifically to it, the nodes of the ATM network shown in FIG. 3, i.e. the remote multiplexer, access, local exchange and tandem exchange nodes, operate only on the ATM cell headers; the 48-byte cell payloads are neither processed nor even read by the ATM network entities.

In addition to the various layers shown in FIG. 4, the protocol layer model for the B-ISDN network of FIG. 3 also includes a management plane responsible for management of all user and control layers within the CP node. The management plane is involved, for example, in the call setup procedures. A layer management entity of the management plane serves to interface each of the user and control layers and is responsible for providing instructions to those layers (either for local management purposes or for transmittal to the management plane of distant CP nodes) and for accepting replies from those layers (either locally generated or generated within the management plane of some distant CP node).

Returning now to FIG. 2, the switching apparatus 21 is provided at a switching node of the ATM network shown in FIG. 3, for example at one of the local exchange nodes (LENS) 114 or at one of the tandem exchange nodes (TENs) 116 thereof. The 4N UNI ports of the apparatus 21 are connected to different respective ATM transmission lines that link the switching node to other switching nodes or to ATM network entities such as the one of the access nodes (AN) 110 or one of the customer premises (CP) nodes 102.

The physical-layer devices 2_1 to 2_N convert the respective bit streams received from the ATM transmission lines connected to the UNI ports into ATM cell streams suitable for delivery to the traffic management devices 24_1 to 24_N which are ATM-layer devices. The functions performed by the physical-layer devices 2 include cell rate decoupling, header error control (HEC) header sequence generation/verification; cell delineation; transmission frame adaptation; transmission frame generation and recovery; and bit timing. The transmission frame adaptation, generation and recovery functions are required because in the physical layer the information may be transmitted in any suitable frame format, for example ITU-T G.707, G.708 and G.709 synchronous digital hierarchy (SDH) format, STM-1 format (155.52 Mbit/s) or ITU-T G.751 plesiochronous digital hierarchy (PDH) E3 format (34.368 Mbit/s). Other suitable formats include fibre distributed data interface (FDDI) *4b/5b* as specified by the ATM Forum.

The respective ATM cell streams produced by the physical-layer devices 2_1 to 2_N are transferred via the respective data delivery paths 6_1 to 6_N to the corresponding traffic management devices 24_1 to 24_N.

FIG. 9 is a schematic view of one of the traffic management devices 24. The traffic management device includes an input portion 32 and an output portion 34. The input portion 32 includes a cell receiving circuit 322, a cell identification circuit 324 and a cell output circuit 326. The cell output circuit 326 has a first port P1 connected to the transmit part of the data delivery path 10 linking the input portion 32 to its associated input port of the switch fabric, and a second port P2 connected to the SAR bus 26 linking the input portion 32 to the SAR device 12.

The cells arriving at the input portion 32 from the physical-layer device 2 are received by the cell receiving circuit 322.

Under the control of the cell receiving circuit 322 the cells arriving at the traffic management device are generally buffered temporarily in a receive memory 36 which may form part of the traffic management device itself or, more usually and as shown in FIG. 9, will be a separate memory device such as a static RAM connected by a bus to the traffic management device. The receive memory 36 may be organised, for example, as a plurality of receive queues RQ_1 to RQ_N corresponding respectively to the N different traffic management devices of the apparatus. A further receive queue RQ_{SAR} is also provided in the receive memory 36, as will be explained in more detail below.

Each receive queue RQ may also be subdivided into a plurality of sub-queues SQ_0 to SQ_3 corresponding respectively to different traffic priority levels. In FIG. 9 priority level 3 (the lowest level) corresponds to available bit rate (ABR) and unspecified bit rate (VBR) traffic, priority level 2 corresponds to non-real-time variable bit rate (NRT-VBR) traffic, priority level 1 corresponds to real-time (RT) VBR traffic, and priority level 0 (the highest level) corresponds to constant bit rate (CBR) traffic.

In the cell identification circuit 324, the cell header of each received cell is examined to determine whether the cell forms part of a signalling message or an inter-host communication message that originated in the host processor of another ATM network entity. Such cells may be distinguished from user-data cells based on the VPI/VCI fields of the cell header. For example, the permanent virtual connections reserved for communication of such signalling and inter-host communication messages may all have the special VCI value of 5 (but any suitable VPI value). This enables the cells belonging to signalling and inter-host communication messages to be distinguished from other cells making up normal data messages.

Examples of signalling messages include messages to set up a call (as described previously) and messages to set up point-to-multipoint connections. Point-to-multipoint signalling messages also use the VCI value of 5 because the individual links are set up separately one at a time. Other examples of dedicated signalling messages include Meta-Signalling messages (VPI=arbitrary (VCI=1) and General Broadcast Signalling (VPI=arbitrary, VCI=2). Inter-host communication messages may include user-defined messages which again are identified by assigning the cells making up the message a special VPI/VCI combination. In addition, inter-host communication messages may also include Interim Local Management Interface (ILMI) communications between adjacent ATM UNI Management Entities (UMEs), as described in more detail in "ATM User-

Network Interface Specification", Version 3.1, Section 4: Interim Local Management Interface Specification. The cells belonging to such ILMI communication messages will also be allocated one or more specific VPI/VCI values (for example VCI=16 and VPI=any suitable value).

When the cell identification circuit 324 determines that a received cell is a user-data cell the destination traffic management device for the cell concerned is identified using a routing table accessible by the input portion, and the cell is stored in the receive queue RQ (and sub-queue SQ if provided) which corresponds to the destination traffic management device (and cell priority level). The fill levels of the different receive queues can be read periodically by the host processor 16 via the host bus 28 so as to enable the host processor to detect congestion in the switching apparatus.

The traffic management devices operate synchronously in successive time slots. In each time slot, the cell output circuit 326 of each traffic management device is permitted to transfer one (or possibly more) ATM cells to another one of the traffic management devices of the apparatus, the switch fabric 8 providing up to N data transfer paths, each between one of its input ports and one of its output ports. The cell(s) is (are) output from the first port P1 of the cell output circuit 326. The selection of which receive queue the cell(s) to be transferred is (are) taken from is made by the cell output circuit 326 in accordance with scheduling information provided to the traffic management device by the host processor 16. In determining the scheduling, the host processor has regard to possible congestion, but also selects the source-destination pairs for the traffic management devices so as to avoid contention problems in the switch fabric. These matters are discussed in more detail in the present assignee's copending United Kingdom Patent Application No. 9617110.3.

After passage through the switch fabric, cells reaching the output portion 34 of the destination traffic management device are again buffered temporarily in a transmit memory 38. This transmit memory may, like the receive memory 36, be organised as a plurality of transmit queues TQ_x to TQ_{x+3}. The transmit queues TQ correspond respectively to the different UNI ports x to x+3 that are controlled by the physical-layer device 2 that is connected to the traffic management device 24 concerned. Each transmit queue may be subdivided into a plurality of sub-queues SQ_0 to SQ_3 which may correspond to the different priority levels (as in the case of the transmit queue TQ_x) or to the different virtual connections VC_W to VC_Z using the UNI port concerned (as in the case of the transmit queue TQ_{x+3}).

When, on the other hand, the cell identification circuit 324 in the input portion 32 of the traffic management device 24 determines that a cell received from its corresponding physical-layer device 2 belongs to a signalling message or inter-host communication message, the cell is stored temporarily in the further receive queue RQ_{SAR} corresponding to the SAR device 12.

The SAR device 12, which is the master device for the SAR bus 26 linking it to the different traffic management devices 24_1 to 24_N, continually polls the traffic management devices to find out whether any of them has received a cell belonging to a signalling or inter-host communication message. If it is informed by one of the traffic management devices that such a cell has been received, it instructs the cell output circuit 326 of the traffic management device concerned to read the cell from the receive queue RQ_{SAR} and to transmit the cell to it via the second port P2 over the SAR bus 26. The transferred cell is then re-assembled with other cells belonging to the same message by the SAR device 12, the payload portion of the cell being treated as the SAR-SDU and (assuming the message is an AAL5 message) the payload type (PT) information in the PT field of the cell header being decoded to extract the ATM-layer-user-to-ATM-layer-user (AUU) parameter which is needed to detect the beginning, continuation and end SAR-SDUs of the message (cf. FIGS. 6 to 8 above). The memory device 14 connected to the SAR device 12 is used to store the individual SAR-SDUs during reassembly of the message. The different SAR-SDUs belonging to the same message provide segments of the CPCS-PDU. This PDU includes the CPCS-PDU trailer added by the AAL function at the source of the message. The length field in the trailer is used by the SAR device 12 to detect loss or gain of information. Similarly, the CRC field is used by the SAR device to detect bit errors in the CPCS-PDU. From the CPCS-PDU payload, the reassembled message (CPCS-SDU) is then extracted and made available to the host processor 16.

Incidentally, the SAR device 12 may also be used to implement the service specific convergence sub-layer (SSCS), if provided, in which case the CPCS-SDU is converted by the SSCS into the required final message (SSCS-SDU) prior to delivery of that SDU to the host processor.

In the host processor 16 the reassembled message is examined and appropriate action taken in response thereto. For example, when a new call is set up, signalling messages are sent by the call processing function of the ATM network to inform the host processor of the VPI/VCI field allocated to cells belonging to that new connection and to identify the UNI ports of the apparatus which the new connection is to use. This information contained in these signalling messages is registered by the host processor 16 and is also used by the host processor to update the switch routing table (or address translation circuit) of the traffic management device which will receive cells belonging to that new connection as they enter the switching apparatus so that that traffic management device routes the cells to the appropriate destination traffic management device.

If the host processor 16 wishes to send, rather than receive, a signalling message or inter-host communication message, it stores the message in the memory 14 ready for segmentation by the SAR device 12. The SAR device 12 treats the message as a CPCS-SDU (if a SSCS is provided in the SAR device 12, then the original message is treated as a SSCS-SDU and first converted into a CPCS-SDU). A CPCS-PDU is then formed, having the CPCS-SDU as its payload, a padding field, and a CPCS-PDU trailer (FIG. 7). The CPCS-PDU is then segmented into SAR-SDUs, and each SAR-SDU is used to provide the payload of an ATM cell. The PT information in the PT field of the cell header is encoded as shown in FIG. 8 to carry the AUU parameter (AUU=0 for cells constituting the beginning and continuation of the message, and AUU=1 for the cell constituting the end of the message). The VPI/VCI values needed to route the cells to the intended destination are also loaded into the VPI/VCI fields of each cell. For example, a permanent virtual connection may have been reserved for communication between the host processor 16 and the host processor in the destination CP node or other switching node. In this case, the special VPI/VCI values assigned to that permanent virtual connection (e.g. VCI=5, VPI value=arbitrary) are loaded into the VPI/VCI fields of each cell.

The SAR device also identifies the destination traffic management device for the cells belonging to the message, which device is the traffic management device whose cor-

responding physical-layer device controls the UNI port from which the cells are to be output from the switching apparatus. The SAR device 12 then transfers the cells via the SAR bus 26 to the destination traffic management device, and the cells are stored in the transmit memory 38 in that one of the transmit queues TQ which corresponds to the UNI port from which the cells are to be output. The cells are then transferred from the transmit queue concerned to the UNI port via the physical-layer device 2 under the control of the output portion 34 of the traffic management device.

It will be appreciated that, unlike the FIG. 1 switching apparatus in which the SAR device was connected to a port of the switch fabric, in the FIG. 2 apparatus the ATM cells making up signalling and inter-host communication messages can be transmitted directly from the traffic management devices to the SAR device. All of the ports of the switch fabric are therefore available for switching cells representing user information, which is the predominant information to be switched. Accordingly, the number of UNI ports which the FIG. 2 apparatus is able to support is greater than that possible with the FIG. 1 apparatus. Furthermore, because the cells destined for the SAR device are diverted directly to the SAR device by the traffic management devices, rather than having to pass through the switch fabric, contention in the switch fabric caused by the signalling and other messages is avoided.

It will be appreciated that, although the foregoing embodiment used AAL 5 communication protocols, this is not essential to the invention and any suitable communication protocols requiring segmentation and reassembly functions can be used in embodiments of the present invention.

Furthermore, although in the foregoing embodiment cells which belong to signalling messages and inter-host communication messages were distinguished from other cells on the basis of the VPI/VCI values assigned to the cells, any suitable method of distinguishing the signalling/inter-host communication message cells from user-data cells can be used.

Another embodiment of the present invention will now be described with reference to FIGS. 10 to 12(D). In this embodiment, as shown in FIG. 10, the switching apparatus is used to implement an Internet Protocol (IP) switch 50 which is arranged between an upstream node 60 of an ATM network and a downstream node 70. The upstream and downstream nodes communicate using Internet Protocols.

Referring now to FIG. 11, which shows the constitution of the switching apparatus 50 in this embodiment, it can be seen that, in addition to the components previously described with reference to FIG. 2, the switching apparatus 50 further includes an IP switch controller 52 having its own memory 54 and a IP switch processor 56. Both the memory 54 and the IP switch processor 56 are connected to the host bus 28 which links the host processor 16 of the switching apparatus to each of the traffic management devices 24_1 to 24_N.

The SAR device 12 is shown in FIG. 11 as part of the IP switch controller 52 but this is not essential and the SAR device 12 could be external to the IP switch controller 52 since it is used both by the host processor 16 and by the IP switch processor 56. The SAR device 12 is connected to the internal memory 54 and the IP switch processor 56 of the IP switch controller 52 by an extension of the host bus 28.

In FIG. 11, the IP switch controller 56 is shown separately from the host processor 16 but, depending upon the size of the switching apparatus, a single processor could be used to provide the host processor 16 and the IP switch processor 56. In this case, the memories 14 and 54 could also be combined as a single memory.

Operation of the FIG. 11 switching apparatus will now be described with reference to FIGS. 12(A) to 12(D).

Incidentally, in FIGS. 12(A) to 12(D), the respective input and output portions 32 and 34 of each traffic management device 24 (see FIG. 9) are shown separately for the purposes of illustration, even though physically, for example, the input portion 32_1 and the output portion 34_1 will both form part of the same traffic management device 24_1.

In FIG. 12(A), the initial operating condition of the apparatus is shown, in which the upstream node 60 has established a predetermined input virtual channel IVC_{DEF} which is used initially as the default forwarding channel for IP packets between the upstream node 60 and the IP switch 50. As shown in FIG. 12(A), it is assumed in this case that the default forwarding channel IVC_{DEF} has, as its source traffic management device, the traffic management device 24_1.

A default output virtual channel OVC_{DEF} is also initialised for use in transferring IP packets from the switching apparatus 50 to the downstream node 70. As shown in FIG. 12(A), in this case it is assumed that the default of the virtual channel OVC_{DEF} is controlled by the destination traffic management device 24_N.

The upstream and downstream nodes 60 and 70 use internet protocols to communicate. IP packets are sent from the upstream node 60 via the switching apparatus 50 to the downstream node 70. These packets may, for example, be up to 64 k bytes in length, and accordingly each packet must be segmented into a plurality of individual ATM cells. Initially, each of the cells has in its header portion a first VPI/VCI combination corresponding to the default input virtual channel IVC_{DEF} when being transferred from the upstream node 60 to the switching apparatus 50, and has a second VPI/VCI combination, different from the first VPI/VCI combination and corresponding to the default output virtual channel OVC_{DEF}, when being transferred from the switching apparatus 50 to the downstream node 70. The necessary conversion from the first VPI/VCI combination to the second VPI/VCI combination is carried out in the switching apparatus, for example by the input portion 32_1 of the source traffic management device 24_1.

When an IP packet is received, cell-by-cell, by the input portion 32_1 of the source traffic management device 24_1 via the default input virtual channel IVC_{DEF}, the individual cells making up that packet are distinguished by the input portion 32_1 from other cells because each cell header has the first VPI/VCI combination corresponding to the default input virtual channel IVC_{DEF}.

For reasons that will be explained in more detail later, the input portion 32_1 passes the cells of the IP packet via the SAR bus 26 to the SAR device 12. In the SAR device 12 the cells belonging to the same IP packet are combined to reassemble the packet using the internal memory 54 of the IP switch controller 52.

The IP switch processor 56 runs intelligent routing software which examines the reassembled packets in the memory 54 for the purpose of identifying so-called IP flows. When examined, network traffic can be classified into short-lived traffic or longer "flow"-oriented transmissions. These flows can be identified either by examining each packet to determine its type, for example file transfer (FTP), or by identifying conversational pairs. Conversational pairs are characterised by a series of packets that contain the same source and destination address. Flows are unidirectional in

nature and lend themselves to being transmitted via a switched connection, thus avoiding processing overhead and delays associated with the examination of each individual packet as in the usual routing process.

The IP switch controller 52 is provided to enable the switching apparatus to detect flows and to deal with packets that are determined to constitute flows differently from packets not identified as constituting such flows. As shown in FIG. 12(B), if a packet does not form part of a flow, it is simply segmented into individual cells again, and the cells are transferred to the input portion of a selected one of the traffic management devices (for example, in FIG. 12(B), the input portion 32_2 of the traffic management device 24_2) for transfer via the switch fabric to the destination traffic management device which in this case is the traffic management device 24_N. From here the cells are output via the default output virtual channel OVC_{DEF} to the downstream node 70. This corresponds to the conventional (store-and-forward) routing process.

Incidentally, the selection of the traffic management device to which the cells of the segmented packets are sent by the IP switch controller may be determined in dependence the prevailing traffic conditions, for example to avoid congestion/contention in the switching apparatus. Alternatively, the segmented cells could always be sent back to the original source traffic management device (24_1 in this example).

However, this conventional process is relatively slow as a whole IP packet must be received, stored and then forwarded by the IP switch controller 52.

If the IP switch controller 52 determines that a flow exists, based for example on the packet type identifier carried by each reassembled packet or upon the numbers of reassembled packets having the same source and destination addresses in a given period, it produces a signalling message A which is transferred to the upstream node 60 via the SAR device 12 (which segments the signalling message into ATM cells) and one of the traffic management devices 24. The signalling message A informs the upstream node 60 that a flow has been detected and requests the upstream node to use a new input virtual channel IVC_{NEW} to send the packets belonging to that flow to the switching apparatus 50, instead of using the default input virtual channel IVC_{DEF}. The switching apparatus 50 proposes a VPI/VCI combination for the new virtual channel IVC_{NEW}.

If the upstream node agrees to the request and the proposed VPI/VCI combination, it sends a signalling message B back to the IP switch controller 52 via one of the traffic management devices 24 and the SAR device 12 and, from this point onwards, sends each cell belonging to packets of the detected flow with the specified VPI/VCI combination corresponding to the new input virtual channel (IVC_{NEW}) in its header.

Simultaneously, the IP switch controller sends a further signalling message C to the downstream node 70 via the SAR device 12 and one of the traffic management devices 24. Like the signalling message A, the signalling message C informs the downstream node that a flow has been detected and requests permission to send the traffic belonging to that flow to the downstream node using a new output virtual channel OVC_{NEW}, instead of using the default output virtual channel OVC_{DEF}. Again, the IP switch controller 52 proposes a VPI/VCI combination for the new output virtual channel OVC_{NEW}. If the downstream node 70 agrees to the request and the proposed VPI/VCI combination, it sends a signalling message D back to the IP switch controller 52.

Once the new input and output virtual channels IVC_{NEW} and OVC_{NEW} have been agreed amongst the upstream node 60, the downstream node 70 and the IP switch controller 52, the IP switch controller 52 programs the traffic management devices in the switching apparatus 50 to route the flow directly in hardware. For example, if as shown in FIG. 12(D) the new input virtual channel IVC_{NEW} delivers cells to the input portion 32_N of the traffic management device 24_N (the new "source" traffic management device), and the new output virtual channel OVC_{NEW} delivers cells from the output portion 34_2 of the traffic management device 24_2 (the new "destination" traffic management device) to the downstream node 70, the IP switch controller 52 programs the new source traffic management device 24_N with suitable address translation data so that cells received via the new input virtual channel IVC_{NEW} are identified and passed by the source traffic management device 24_N via the switch fabric to the destination traffic management device 24_2, from where they are output to the downstream node 70 via the output virtual channel OVC_{NEW}. Accordingly, cells belonging to the detected flow are no longer transferred by the source traffic management device 24_N to the SAR device 12 for reassembly and routing, but are transferred cell-by-cell "automatically" through the switching apparatus. The IP switch controller 52 effectively reserves suitable bandwidth BWRES between the source traffic management device 24_N and the destination traffic management device 24_2 for transferring the cells belonging to the flow through the switching apparatus.

The ability for the detected flows to bypass the IP switch controller enables the switching apparatus to forward packets belonging to such flows at rates limited only by the aggregate throughput of the underlying switch engine. Furthermore, because there is no need to reassemble ATM cells into IP packets in the switching apparatus, throughput remains optimised throughout the network.

Although in the above example, the switch to the input virtual channel results in a change of source traffic management device, it will be appreciated that in other instances the source traffic management device could be the same both for the default and new input virtual channels, for example when there is only one physical path linking the upstream node 60 to a single UNI port of the switching apparatus (in this case only the VCI would need to be changed to select the new virtual channel, the VPI staying the same). The same applies to the destination traffic management device used to service the new output virtual channel. It may or may not be the same traffic management device used to service the default output virtual channel, depending on the arrangement of physical paths between the switching apparatus and the downstream node.

In the embodiment described with reference to FIGS. 10 to 12(D) the SAR bus 26 is utilised to send packets that are to be routed on the default store-and-forward basis by the IP switch controller 52 from the source traffic management device to the IP switch controller 52. Accordingly, it is not necessary to connect the IP switch controller to a port of the switch fabric, thereby leaving all ports of the switch fabric free for connection to traffic management devices.

The SAR bus 26 may also be used to convey cells belonging to the signalling messages A to D needed to alert the upstream and downstream nodes to the flows (although the signalling messages could also be delivered to the traffic management devices via the host bus 28, if preferred).

What we claim is:

1. Switching apparatus, for use in an ATM network, comprising:

a switch fabric for switching ATM cells;

a reassembly portion for reassembling packets from ATM cells; and

a traffic management portion connected for receiving ATM cells delivered to the apparatus and also connected by a first data delivery path to said switch fabric and by a second data delivery path, separate from the first data delivery path, to said reassembly portion, and operable to identify as respective reassembly cells those cells amongst the received ATM cells that require reassembly by the reassembly portion, and to deliver received cells other than such identified reassembly cells to the switch fabric via said first data delivery path for switching by said switch fabric and to deliver said reassembly cells to said reassembly portion via said second data delivery path for reassembly into packets by the reassembly portion.

2. Apparatus as claimed in claim 1, wherein the cells identified as reassemble cells comprise cells belonging to packets constituting signaling messages.

3. Apparatus as claimed in claim 1, further comprising a host portion for controlling operation of the apparatus, which host portion is connected operatively to said reassembly portion for receiving therefrom such packets reassembled by the reassembly portion.

4. Apparatus as claimed in claim 3, wherein the cells identified as reassembly cells comprise cells belonging to packets constituting inter-host communication messages directed to said host portion of the apparatus by the host portion of another ATM-network-entity.

5. Apparatus as claimed in claim 1, wherein the cells identified as reassembly cells comprise cells belonging to packets constituting ATM Adaptation Layer (AAL 5) messages.

6. Apparatus as claimed in claim 1, wherein said traffic management portion comprises a cell identification portion operable to examine virtual-path-identifier and/or virtual channel-identifier fields of a header of each received ATM cell and to determine, in dependence upon the results of such examination, whether the received cell is to be identified as such a reassembly cell.

7. Apparatus as claimed in claim 1, further comprising a segmentation portion, connected to said traffic management portion by said second data delivery path, and operable to segment a packet generated locally in the apparatus into a plurality of ATM cells and to deliver the cells of said plurality to the traffic management portion via said second data delivery path.

8. Apparatus as claimed in claim 7, wherein said second data delivery path comprises respective unidirectional transmit and receive paths, the receive paths serving to deliver the identified reassembly cells from the traffic management portion to the reassembly portion, and the transmit path serving to deliver the cells of said plurality from said segmentation portion to the traffic management portion.

9. Apparatus as claimed in claim 7, wherein said segmentation portion and said reassembly portion form part of the same segmentation-and-reassembly device.

10. Apparatus as claimed in claim 1, wherein said traffic management portion comprises a plurality of individual traffic management devices connected respectively to said switch fabric by said first data delivery path for exchanging ATM cells via data transfer paths provided by the switch fabric, and said second data delivery path comprises a bus connecting the individual traffic management devices in common to the reassembly portion.

11. Apparatus as claimed in claim 10, wherein said bus is a Universal-Test-and Operations-PHY-Interface-for-ATM (UTOPIA) level 2 lookalike bus for connecting ATM-layer devices to physical-layer devices.

12. Apparatus as claimed in claim 1, further comprising:

at least one data port for connection, when the apparatus is in use, to an ATM-network transmission line carrying a bit stream; and

a physical-layer portion connected between said traffic management portion and said at least one data port for converting the bit stream into one or more corresponding ATM cell streams for delivery to said traffic management portion.

13. Switching apparatus, for use in an ATM network, comprising:

a switch fabric for switching ATM cells;

a segmentation portion for segmenting a packet generated locally in the apparatus into a plurality of ATM cells; and

a traffic management portion connected by a first data delivery path to said switch fabric and by a second data delivery path, separate from said first data delivery path, to said segmentation portion, and operable to receive from the switch fabric via said first data delivery path cells that have been switched by the switch fabric and to receive from the segmentation portion via said second data delivery path the cells of said plurality, and to output an ATM cell stream comprising the switched cells received from the switch fabric and the cells of said plurality received from the segmentation portion.

14. A traffic management device, for use in an ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having a reassembly portion for reassembling packets from ATM cells delivered to the apparatus, the traffic management device comprising:

a cell receiving portion for receiving ATM cells;

a cell identification portion connected to said cell receiving portion and operable to identify as respective reassembly cells those cells amongst the received cells that require reassembly by said reassembly portion of the apparatus; and

a cell output portion having a first port portion adapted for connection, when the device is in use, to said switch fabric, and also having a second port portion, separate from said first port portion, adapted for connection when the device is in use to said reassembly portion, and operable to deliver received cells other than the identified reassembly cells to said first port portion and to deliver said reassembly cells to said second port portion.

15. A device as claimed in claim 14, wherein said cell identification portion is operable to examine the virtual-path-identifier and/or virtual-channel-identifier fields of the header of each received ATM cell and to determine, in dependence upon the results of such examination, whether or not the cell concerned is to be identified as such a reassembly cell.

16. A traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having a segmentation portion for segmenting packets generated locally by the apparatus into a plurality of ATM cells to be output from the apparatus, the traffic management device comprising:

a cell input portion having a first port portion adapted for connection, when the device is in use, to said switch fabric, and also having a second port portion, separate from said first port portion, adapted for connection when the device is in use to said segmentation portion, and operable to receive at said first port portion cells that have been switched by the switch fabric and to receive at said second port portion the cells of said plurality; and

a cell output portion for outputting any ATM cell stream comprising the switched cells received from the switch fabric and the cells of said plurality.

17. Apparatus as claimed in claim 1, wherein the cells identified as reassembly cells comprise cells belonging to internet-protocol packets, and the apparatus further comprises an internet-protocol switch controller portion connected with said reassembly portion for examining such reassembled internet-protocol packets to detect packet flows through the switching apparatus.

18. Apparatus as claimed in claim 17, wherein the traffic management portion is operable, in a default routing mode thereof, to receive such internet-protocol packets from an upstream node of the ATM network via a predetermined default input virtual channel and to identify, as such reassembly cells, received ATM cells belonging to said predetermined default input virtual channel and to deliver those cells via said second data delivery path to said reassembly portion so as to permit said internet-protocol switch controller portion to detect packet flows from examination of the reassembled packets, and being switchable, upon detection by said internet-protocol switch controller portion of such a packet flow, to operate in a cut-through switching mode in which the cells of subsequent packets making up the detected packet flow are received by the traffic management portion via a new input virtual channel, different from said predetermined default input virtual channel, and are not identified as such reassembly cells and are delivered directly to the switch fabric via said first data delivery path.

19. Apparatus as claimed in claim 18, wherein reassembled packets not detected by said internet-protocol switch controller portion as belonging to a packet flow are segmented into a plurality of cells which are transferred back to the traffic management portion for delivery to said switch fabric.

20. Apparatus as claimed in claim 19, wherein, after passage through said switch fabric, the cells of said plurality are output to a downstream node of the ATM network via a predetermined default output virtual channel.

21. Apparatus as claimed in claim 18, wherein:

reassembled packets not detected by said internet-protocol switch controller portion as belonging to a packet flow are segmented into a plurality of cells which are transferred back to the traffic management portion for delivery to said switch fabric;

after passage through said switch fabric, the cells of said plurality are output to a downstream node of the ATM network via a predetermined default output virtual channel; and

during operation of the traffic management portion in said cut-through switching mode, the cells of said subsequent packets making up the detected packet flow are output by the traffic management portion via a new output virtual channel, different from said predetermined default output virtual channel.

22. Apparatus as claimed in claim 18, wherein, upon detection by said internet-protocol switch controller portion of such a packet flow, the traffic management portion is caused to reserve bandwidth for switching the cells of the detected packet flow via said switch fabric.

23. Switching apparatus, for use in an ATM network, comprising:

a switch fabric for switching ATM cells;

an internet-protocol switch controller portion for detecting internet-protocol flows through the switching apparatus;

a traffic management portion connected for receiving ATM cells delivered to the apparatus and also connected by a first data delivery path to said switch fabric and by a second data delivery path, separate from the first data delivery path, to said internet-protocol switch controller portion, and operable, in a default routing mode thereof, to identify, as default-routing cells, those received ATM cells that make up packets not detected as belonging to such an internet-protocol flow and to deliver those cells via said second data delivery path to said internet-protocol switch controller portion; and

the traffic management portion also being operable in a cut-through switching mode in which the received ATM cells that make up packets belonging to such an internet-protocol flow are delivered directly to said switch fabric via the first data delivery path.

24. Apparatus as claimed in claim 23, wherein the traffic management portion serves in said default-routing mode to receive the cells making up packets via a default input virtual channel, and is switchable, when the internet-protocol switch controller portion detects that the packets constitute an internet-protocol flow, from the default routing mode to the cut-through switching mode, in which said traffic management portion serves to receive the cells making up subsequent packets of the detected flow via another virtual channel, different from the default input virtual channel.

25. A traffic management device, for use in an ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having internet-protocol switch controller portion for detecting internet-protocol flows through the switching apparatus, which device comprises:

a cell receiving portion for receiving ATM cells;

a cell output portion having a first port portion adapted for connection, when the device is in use, to said switch fabric, and also having a second port potion, separate from said first port portion, adapted for connection when the device is in use to said internet-protocol switch controller portion; and

a cell identification portion connected to said cell receiving portion and operable, in a default routing mode thereof, to identify, as default routing cells, those received ATM cells making up packets that have not been detected as belonging to such an internet-protocol flow and to deliver those cells to said second port portion for transfer to the internet protocol switch controller portion, and also operable in a cut-through switching mode in which those received ATM cells making up packets that have been detected as belonging to such an internet-protocol flow are delivered to the first port portion for transfer directly to the switch fabric.

26. A switching method, for use in ATM network switching apparatus that comprises a switch fabric for switching ATM cells, a reassembly portion for reassembling packets from ATM cells, and a traffic management portion for receiving ATM cells delivered to the apparatus, said method comprising:

identifying cells amongst the received ATM cells that require reassembly by the reassembly portion by the traffic management portion as respective reassembly cells;

delivering received cells other than such identified reassembly cells by the traffic management portion to the switch fabric via a first data delivery path;

switching the delivered cells by the switch fabric; and

delivering the identified reassembly cells are from the traffic management portion to the reassembly portion via a second data delivery path separate from the first data delivery path, and reassembling the delivered and reassembled cells into packets by the reassembly portion.

27. A switching method, for use in ATM network switching apparatus that comprises a switch fabric for switching ATM cells, a segmentation portion for segmenting a packet generated locally in the apparatus into a plurality of ATM cells, and traffic management portion for outputting switched cells, said method comprising:

receiving cells that have been switched by the switch fabric by the traffic management portion from the switch fabric via a first data delivery path;

receiving the plurality of cells produced by the segmentation portion by the traffic management portion via a second data delivery path separate from said first data delivery path; and

outputting an ATM cell stream, comprising the switched cells received from the switch fabric and the cells of said plurality received from the segmentation portion, by the traffic management portion.

28. Apparatus as claimed in claim **10**, wherein:

said reassembly portion is operable as a master device of said bus and each traffic management device is operable as a slave device of said bus; and

said reassembly portion comprises:

a polling portion for polling the traffic management devices to determine if any of them has identified a received ATM cell as being such a reassembly cell; and

a data reading portion operable, if it is determined by said polling, portion that one of said traffic management devices has identified such a reassembly cell, to cause the traffic management device having that cell to deliver it to the reassembly portion via said bus.

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